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ARCHITECTURE

VAULT

# ELEMENTS AND THEORY
# of
# ARCHITECTURE

By

J. GUADET

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Volume I

PARIS.

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Urbana. Ill.

1916

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# Preface to the third Edition.

## Note on the Life and Works of Julien Gaudet.

(December 23, 1834--May 17, 1908).

By

J. L. Pascal.

Member of the Institute, Inspector General of Civil Buildings

In one of those paradoxical caprices of thoughtful boldness in which his genius indulged, our master Garnier said that for the architect, the classical is everything that constructs.

In giving to that formula emphasis by the most cautious selection, Julien Gaudet, the author of this beautiful and good book, for any reason would not have to present it for a new edition, but death arrested the masterly and calm production of that balanced mind, very particularly delighting in educational labors, soon after he had completed the preparation of this third issue, nearly similar to the second.

He is no more! For several generations that remember the brilliant pupil of the School of Fine Arts, the strong pensioner of the French Academy at Rome, the inspector of works at the Opera House and the Museum of Natural History, the architect of the Post Office at Paris, and of the reconstruction of the French Theatre; for the government officials or men of affairs, that have met in business the inspector general of civil buildings, the well appreciated expert, the masterly author, accurate and literary, of so many official reports almost educative on the most diverse matters; for enthusiasts in higher studies, who have appreciated the instruction by a chief of an atelier, that had become a professor for all students in Rue Bonaparte, who introduced to their minds architectural theories for the numerous artists in the entire world, that unconsciously were impressed, it would only be necessary to make known what was represented by that serene kindness and uniform temper, the noble figure at the beginning of this volume, and also his continual graces in the service of not only the youths, that were directly under him, but to all those believing it right to have him intervene in their affairs.

For the future alone is it necessary to note how the systematic plan of the work of my dear friend is in harmony with the charming existence of the artist, in which rank posterity

will place him, if the word be not too ambitious in speaking of an architect.

In the first pages the inexperienced youth finds a guide for deciding the choice of his career, an inspirer able to aid his enthusiasm, as well as an adviser directing him from too many illusions, if it be prudent for him not to commence at random in the series of studies preceding the most laborious of careers. Before and during his severe apprenticeship, the pupil having taken his course, will have ascertained the multiplicity of the knowledge to be acquired, the scientific possessions continually increasing, that must be accumulated; but while showing him the happy results of his efforts, the small joys destined to become great enthusiasms, the leader will have reassured him in regard to the final end by warning him constantly, that each day suffices for its toil, that every difficulty is surmounted, and that unconsciuosly he will reach that certainty which produces continual solutions, spontaneity of finds, ingenuity and flexibility, that are the aims of the beautiful entirety of the theories contained in the summary of the lectures of the master.

After having seen what can inform, instruct and elevate him, the artist that he is to train, to whom has been furnished even the description of the instruments that he will have to use, this informed disciple will find at once the rule of conscience, that must precede all operations of his mind, all his efforts in creation, the embodiment of his contrivances, the protection of the interests in his charge. Later he will find the indications of the sad temptations which he must avoid, the duties incumbent upon him toward individuals, the government, cities or communities that trust him.

The practician, even he that has conquered all the difficulties of his career will find there summarized in a sort of code the enumeration of the duties, -- not often the laws - to which he must submit his scrupulous conduct under severe discipline, -- so good that a part of the work has been adopted by the oldest of French Societies as the rule of the conduct of its members.

This feeling of responsibility elsewhere vaguely dominates in the entire course of composition, more particularly formulated in the last pages, and summarized in the final word; - honor.

Between the preparation in the beginning and the final suggestions of such high character, for the practice of a noble profession, there extends in a very intelligible order the enumeration of the elements composing the construction, the explanation in practical pages accompanied by historical examples of the procedures in foundations, the varied description of the materials employed in the structure, and the interminable list of elements:- piers, walls, floors, roofs and coverings for enclosing small spans as also great areas, vaults, chambers, stairs, etc., our entire vocabulary.

Reading the table of contents will admirably summarize this long analysis of means, evidence of which has been left to us by the history of our art, adding thereto suggestions of those without the sanction of centuries of duration, even concerning the most risky procedures, that long experience alone permits statement in their turn, as done for those preceding.

There are sufficient illustrations,-- not too many to risk submerging so rich a text,-- comprising an accumulation of examples, all taken from the best sources, faithful, serious and accurate, in which one can confide, frequently reduced from great plates made for the course of lectures at the School of Fine Arts, or borrowed directly from great publications, and beautiful works, commencing with the youthful studies of the master, extending to the examples furnished by his sojourn at Rome and his travels as pensioner into Greece and the Orient.

Then are the considerations that permit combining these elements to be combined to form a complete organism with the details that the anatomy has shown, after the synthesis being the analysis, the breadths of the solids, the proportions of the voids, the nomenclature of courts, porticos, entrances, stairs, etc., of all terms peculiar to us, or those used by all, the whole ending in the composition of plans embodying the given programmes, to the study of elevations and sections of edifices, superposing character on the solutions obtained, and finally art, exclusively pursued by means of so much knowledge.

The fine success-- exceptional in publications-- of this architectural encyclopedia has been a just subject of pride, a triumph for its author, cruelly treated by disease. Indeed, one can say that it summarizes the actual state of our sciences, of tradition and recent invention, of history and experience in progress, of theory and reality, and that for a long

time one will not even refer to any other plan or statement to indicate the evolution in our art. The fixing of this stage will represent, if one desires to seek an equivalent, more than the surveys of a Vitruvius, the statements of a Philibert Delorme, the studies of a Du Cerceau, the information of a Blondel, the notations of Rondelet, of Blouet, of Leonce Raynaud, etc., because never has such a number of examples been collected under the severe control of the firm and lucid mind of a practician so experienced, with the fixed intention of treating as an artist the art of building in its relations to our civilization.

Perhaps one will find that in this rapid analysis of one of the best educational works of this time, my friendship for its author may have counted too much on the knowledge we had of the high personality of this representative of French art, as I have said in commencing, and that it would err too much by preterition, when the work will carry its ideas afar, or transmit them to the generations that will follow us, than not to speak here at greater length of his life, because obituary articles have been devoted elsewhere to him.

Let us then summarize his laborious existence.

Julien Gaudet was born December 23, 1834 at Paris.

This descendant of a Girondist family, one member of which, his great uncle, had already made the name illustrious by leaving a trace in the political life of our country during the French revolution, and had allied himself by his marriage with a fine family of Marie, known so respectably since the part that it took in the revolution of 1848, and later by the marriag of his daughter into the great family of Carnot, whose name is so nobly associated with the republican government.

Led by quite personal tendencies to regard in the career of the arts the special branch of architecture as more in harmony with his faculties, capable of knowing the scientific part equally with the artistic evolution-- to the point of serving while quite young as master and guide in the instruction of his comrades, at the same time after severe classical studies, that he prepared himself for admission to the School of %ine Arts, he passed the finest career there as a pupil, until he obtained in 1864 the prize of Rome, that consecration of a single man each year, with the best efforts added to natural gifts.

His success in these designs was particularly fruitful, and several of his drawings have been added as examples to the instructive text, whose ideal utilities we present, and placed it without a peer.

Before his departure and the general staff, he had taken active part in the preparations and the beginning of the execution of the Opera House of Paris, under the direction of our chief Garnier. On his return and under his master André, he was attached to the works of the Museum of Natural History, which he left only to direct the construction of the great preliminary structures for the Post Office, before the ruins of the Tuileries, while he executed the construction of the permanent edifice, where the smallness of the site is so evident today, and was for him the chief cause of the effort so great for him.

In 1871 he assumed the direction of one of the ateliers, that had been created some years earlier at the School of Fine Arts, before becoming the pupil of André he had attended the lectures of an eminent master, Labrouste. For twenty years in his turn, by that individual method of care, he trained a generation of pupils, whose attachment to him was a noble recompense till his last hour, and that remains faithful to his memory. When he left that position for the functions of professor of theory, his instruction, so appreciated for his oral lectures and still more for the incredible variety, the logical sequence, the careful preparation of the programmes of competitions, could not give him the gentle satisfaction received in the first part of his career as instructor; but his high conscientiousness led him to prepare himself and to maintain it, which gave birth to the numerous manuscripts, transformed into this beautiful work, whose merits we acknowledge: the Elements and Theory of Architecture.

Great length would be necessary to detail the services, that he rendered as architect and inspector of civil buildings in order to make his career known. The most unexpected incident, the burning of the French theatre, gave him opportunity to exhibit his coolness, his talent as constructor, his high professional skill in the removal of the rubbish and the rapid reconstruction of those smoking ruins; he showed himself there as of the first order; whatever his personality attracted, until the presidency of the Central Society of Architects, under terrible circumstances he was almost brutal, braving suffering and menacing death, in order to accomplish what he

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regarded as a duty.

An appreciated and experienced expert, he showed himself also versed in jurisprudence, so that he made himself heard at the Superior Council of Instruction of the School of Fine Arts and at the University; his authority at the General Council of Civil Buildings, the truth of his words like the qualities of his writings also gave him there the highest place until the last hour.

There was necessary the continuance of a strange disease a and almost the sad decision to seek in the South at Lugano a change of air, that was fatal to him, when the disease attacked a resistant constitution, where the mind and power of work was undiminished till the final hour.

To complete these statements concerning such a noble figure, it is unnecessary to say that the qualities of a private man, of a man of family, were at the elevation of the exceptional gifts, of which we have given but a brief idea, and that always ready to render service, his sincere kindmess without triteness, was open to whoever had recourse to him.

He was a fine specimen of humanity, so that the present work, careful and scrupulous, shows one of the many sides under which he merits being given as an example.

April 27, 1909. J. L. Pascal.

## PREFACE TO THE FIRST EDITION.

The origin of this work is twofold, and in a certain sense it has two authors.

Since 1872, I have always had the honor and the serious responsibility of teaching architecture; for twenty-one years as director of an atelier with interesting students, I found that primary or basic knowledge was too frequently lacking with our students, a blank not to be filled later. A professor greatly regrets to see a gifted young man, earnest and industrious, arriving poorly prepared for the studies, merely simple instruction, undigested, with not even the most rudimentary notions of the serious and elevated nature of the studies, without methodical preparation or a mental view of the realm of art. If the soil be still virgin and without false preliminary instruction, which often produces an indelible stain, one may hope, for the task of the professor will be difficult, but fruitful. If the poor student comes already formed, as often said, the professor must gently and unavoidably inform him, that it is too late!

All that have taught know this and cannot contradict it. Why this result?

Evidently for many reasons, but perhaps chiefly because there is no reason that interests for those beginning to study architecture, neither for those undertaking to teach them its elements. This task of the pupil and the master I desired to attempt and began its preparation, a considerably hard, interesting and useful, that I might succeed in after more than twenty years of teaching and of experience of the defects in students.

This book, in my opinion, should be called "The Elements of Architecture".

But I have since been charged with the course in " Theory of Architecture" at the School of Fine Arts. This course was conceived by me in time and comprises the instruction in the principles of architecture. Its general programme is copied here as follows:—

NATIONAL AND SPECIAL SCHOOL OF FINE ARTS.

Programme of Course in Theory of Architecture.

"This course has for its object the composition of edifices in their elements and ensemble, with the twofold view of the

## PREFACE TO THE FIRST EDITION.

The origin of this work is twofold, and in a certain sense it has two authors.

Since 1872, I have always had the honor and the serious responsibility of teaching architecture; for twenty-two years as director of an atelier with increasing numbers, I found that primary or basal knowledge was too frequently lacking with our students, a blank not to be filled later. A professor greatly regrets to see a gifted young man, earnest and industrious, arriving poorly prepared for the studies by merely chance instruction, undigested, with not even the most remote idea of the serious and elevated nature of the studies, without methodical preparation or a mental view of the realm of art. If the soil be still virgin and without false preliminary instruction, which often produces an indelible stain, one may hope, for the task of the professor will be difficult, but fruitful. If the poor student comes already formed, as often said, the professor must generally and conscientously inform him, that it is too late!

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Programme of Course in Theory of Architecture.

"This course has for its object the composition of edifices in their elements and entirety, with the twofold view of the art and of education in definite programmes and in material requirements."

"In the first part will be successively studied the elements proper, i.e. walls, orders, arcades, doors, windows, vaults, ceilings, roofs, etc.; then the more complex elements, such as halls, vestibules, porches, porticos, stairs, courts, etc."

" In the second part, after having established the general principles of composition, will be studied the principal classes of edifices:-- religious, civil, military, for public purposes and private dwellings, giving for each the more remarkable examples in all epochs and countries, showing the needs satisfied by them, then explaining how and to what extent these requirements are modified in case of existing needs and the most recent programmes."

The material is evidently very great, both elementary and advanced, for all studies are elevated studies.

For this course it was necessary to study anew what I had studied forty years since, to condense into tangible formulas what is often merely an instinct, to essentialize acquired experience, and as much for myself as for my young hearers, whose ever interesting contacts have been the best reward for my efforts.

Naturally I must work over and complete what I had first prepared for beginners, and while always progressing toward the elements, the basis of all study, I must touch on subjects formerly forbidden; while on the other hand I could not in this course more than recall the elements with emphasis, yet not explaining them in detail as an integral part of this instruction.

I have frequently been asked if I would not publish this course. There is certainly material for an interesting work, whose natural title would be "Theory of Architecture."

Indeed a useful book, though incomplete because lacking the fundamental elements. If the book prepared by the professor of the atelier should then and strictly,-- a defect easily remedied,-- that made by the professor of theory could only begin at the second stage of the journey.

Then a work really useful to both those commencing or advanced in their studies, must combine the two programmes--the explanation of the elements--the theories resulting from them.

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Thus a work really useful to both those commencing or advanced in their studies, must combine the two programmes:-the explanation of the elements--the theories resulting from them.

I have combined both, adding the first elements of the course in theory, the more logical since dividing lines are quite arbitrary, and if a book may be incomplete when assuming primary studies as already completed, yet the book ought to be complete, when from the primary studies result all the rest, just as an explanation of the fortunate choice of the first path.

Hence this work should receive the title resulting naturally from this twofold purpose:--

ELEMENTS AND THEORY OF ARCHITECTURE.

Yet only the initial theory, since for its later and more elevated portion, the general composition of edifices, this would exceed my limits. If this subject be taken up later by myself or another, this would be another work, and its conception would then be determined. Now I must limit myself, for the study of architecture is too vast to be comprised in a few volumes; to review the monuments rather than the means of architecture would require more than an elementary work.

Thus I hold to its well marked character as an elementary work. Just as in teaching literature are the transcendent lectures of Villemain and of Nisard, with more modest textbooks signed by Burnouf or Quicherat, it is the classbook within reach of beginners that I desire to publish.

And why? Because it is lacking.

Since I have had the honor of teaching architecture, abnormal things have frequently occurred. Young men intending to study our art--or their relatives--have requested me to name an elementary work for guiding them in their first labors, or to prepare them for the time of specializing in their studies. The same question has evidently been put to all teachers, and all alike have replied, that such a work does not exist. Vignola is indeed found, who represents a sort of theory. or rather tables of proportions of the orders of architecture; there are excellent works, like those of Rondelet or Reynaud, but not elementary; also dictionaries in which occur elementary matters beside more elevated discussions. These works are later excellent for reference, but cannot present the logical order of the studies, because arranged by chance alphabetically, first defining "abacus", certainly not the first thing to be known. and several volumes later is found "wall", which indeed should appear before abacus in the study.

Yet every art or science has its elementary books as guides for the beginner, and if logic and connection impose something, this certainly is when young men commence a study, of which they have no idea. Why this lack?

Doubtless the list of architectural publications is rich; men of great talent have made known the most beautiful monuments, some like Penrose devoting themselves to a marvellous edifice and a minute analysis of its details; others like Letarouilly spending an entire life in drawing the edifices of a city unequalled in the arts; others proceed by comparison, thoroughly treating everything relating to a family of buildings; finally are very numerous monographs of past or contemporary monuments. All these form a precious library and a very rich collection, our art in this respect having no need to envy any other branch of knowledge.

Indeed it is evident that enthusiastic artists may have been induced by a fine subject or its novelty to reproduce it definitely and completely. This is more attractive than the composition of an instructive work for beginners. What is most interesting in teaching is the advice given to the more advanced students, but not the instruction of beginners. Perhaps experience in teaching is necessary to show the great need of the book mentioned by me.

Moreover this experience exhibits the difficulty of composing such a work. Artists enriched by study understand each other by hints; it is here necessary to speak a language unknown to the readers; demonstrations are required, never counting on the impression aroused nor on the still latent taste; to proceed as in a science, while an art is to be exhibited; finally to avoid dryness that repels; to initiate into still confused artistic enjoyment, to promise and show rather than supply; to inspire confidence and arouse ardor, in brief to say to young readers; "endure my book because necessary, then shall you enter the promised land."

I have undertaken this work, truly fearful, only because convinced of its usefulness, particularly if kept within the limits of my subject; the theoretical elements of architecture. Perhaps it may be necessary to explain my meaning in these words.

Architecture has a single very clear and apparent reason

for existence; to construct. This word sums all the functions of the architect, to preserve, maintain, repair or restore is still to construct.

To construct is both the purpose and means of the architect; by the etymology of the word "architect" we find its exact sense, which is a definition; "master constructor."

But if construction plays a great part in architecture; it only appears by its general and elementary laws and needs at the beginning of the studies and researches in art; on the contrary the scientific study of its means and problems, the control of its combinations can only come later, when the student already has a sufficient idea of the forms and resources of architecture; at first must be shown what is constructable; he will later see by what means the construction can be ensured, i.e., the realization of something previously conceived.

Thus tha studies proposed for beginners are preliminary to those of construction, comprising only ideas of constructability; I also show them that from these ideas are derived the architectural forms, but I do not explain to them the science of construction. They will find this in the precious work of the lamented Professor Brune; I do not have to touch on the subjects treated by him in a definite manner.

I shall proceed no further than to composition, i.e., to the solution of the programme. To compose is to use what one knows. Composition has its materials just like construction, and these materials are the elements of architecture.

Besides, composition escapes from rules and formulas, it is evidently acquired, but scarcely comprises theoretical instruction. It is entirely personal and the part of good fortune in it is great; so that today one finds for a programme quite a happy composition, but perhaps nothing for yesterday or tomorrow.

The assured role of instruction is then to prepare for composition, to collect its materials, and such must be the purpose of the primary studies, that cannot be too thorough. Indeed students at first are quite impatient in composition; because in its tests for admission to the School of Fine Arts a sketch is required from them, they desire to learn to make a sketch without preparation, i.e., a small composition. A bad method and necessarily sterile, too strongly recalling for candidates.

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sition. An example will explain this.

Form and often limited area of site, access, vicinity, and
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certain things must be understood before; a classroom, yard,
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complex, from known to unknown; I hope to show that in archi-
dences of art; later the complex and refined elements,

schools preparing for examinations, which are termed "ovens" for candidates.

In the most modest composition, for example a guardhouse, there will always be walls, doors, windows, a cornice, a roof etc. What can be done with this subject when one is ignorant of a door, window or cornice? Now beginners in haste to compose do not know these. Learn them.

There is evidently the first object of studies; always with the reserve that no portion of the studies can be considered as completed. The pupil is taught how without great faults to lay out a door or window; but in his entire life, if truly an artist, he will be ambitious to learn how to make a door or window; he will see that antiquity, then Bramante and Sangallo, Duc or Duban in our time, have well shown the difficulty and nobility of this study, that I term elementary because these are really the elements, yet no less elevated than any other.

Yet these heights escape us, we can teach only what is proved logically or by incontestable authority and tradition. Nothing appertains to us beyond instruction.

Yet the explanation of the theoretical elements of architecture would be incomplete if limited to this programme. Between the elements of architecture, such as the door or window, and general composition is a place for the elements of composition. An example will explain this.

Assume that an architect is charged with making a project for a school group. The more or less extended programme, the form and often limited area of site, access, vicinity, and special requirements make the study of the plan more or less laborious, more or less prefect; this is composition. But certain things must be understood before; a classroom, yard, restaurant, room for drawing etc. These are elements of the composition, and these may be taught up to a certain point.

That is the modest purpose of this work.

For method, I seek always to pass form the simple to the complex, from known to unknown; I hope to show that in architecture all proceeds by reasoning. The student should repeat what the labor of centuries has done before him; to recognize first the primary needs, the primary means and the first evidences of art; later the complex and refined elements, [illegible] compound elements, a gradual advance that will also be his [illegible] be the verification of experimental progress.

[illegible]

I neither entertain instruction that in the name of the [illegible]

[illegible]

[illegible] object of dilettanteism or an enigma, nor upon exceptions [illegible]

[illegible] students an inventory as systematic as possible of the acquired patrimony of architecture; I say to them, "know first, [illegible] freedom."

There may indeed be presented objections.

[illegible] be said; art does not so proceed, it consists of inspirations and finds, and by restricting the student in your [illegible] all that he may unwittingly have received from the earliest [illegible] themselves also created for more complicated requirements; he must see that there is a connection between these simple and compound elements, a gradual advance that will also be his aim; he will thus see the logical development of his art, he will comprehend the progress through centuries of that work in which every civilization has cooperated, and which continues to obey the eternal law of movement and of transformation.

Thus I do not adopt for our studies the conventional starting point, and if I did not fear to appear pedantic in employing a too ambitious word, I should say that our method would be the verification of experimental progress.

Such a method cannot be exclusive. Like every artist, I may have my preferences and aversions, but as professor I have never conceived a narrow creed nor excommunication.

I neither entertain instruction that in the name of the antique rejects the middle ages, nor that in the name of the middle ages, which shuts itself between two screens or Chinese walls, one concealing the past and the other the future.

"Nothing concerning man is foreign to me," which may be translated for us; "nothing artistic should remain outside our studies."

But I do not have to touch upon what for us can only be an object of dilettanteism or an enigma, nor upon exceptions due to frequently charming fancies, but whose exceptional character leaves them outside our theoretical studies.

Modestly--and that is already laborious--I place before students an inventory as systematic as possible of the acquired patrimony of architecture; I say to them, "Know first, then choose; knowing from instruction, you will select with freedom."

Here may indeed be presented objections.

Your method is merely a word, a scientific expression, may be said; art does not so proceed, it consists of inspirations and finds, and by restricting the student in your deductions and your series, you falsify his ideas and aspirations; let him do like us, see, try everything, explore perhaps by chance, there will remain something, all this will be piled and arranged; by forging hwe will become a smith, and a fine day comes to exhibit him as an artist by all his attempts, and by all that he may unwittingly have received from the enclosing

atmosphere of his artistic studies.

--Certainly, and I shall also say; nothing is better for the beginner than association with true artists, examples, good influences, even premature ambitions, presumptuous rivalry or chimerical reveries. To one without ardor and confidence must be said; abandon artistic studies not made for you! And I should regret if it were believed, that I labor for small pleasure, for those not gifted with the two mortal sins; of the first necessity to the artist; pride and ambition. Yet my readers are but beginners and will remain such at the end of the book. Later they will extend their studies and enter on the free career of boldness, of personal attempts and perhaps of finds. Teaching indeed has its limits; no one could teach Ictinus how to make a Parthenon, for the master did so; instruction would not suffice to cause the conception of the facade of Notre Dame, the domes of S. Peter or of the Invalids, or the Place de la Concorde. But the authors of these beautiful structures disposed of materials and made use of tested elements. I do not pretend to guide for the entire journey; only to indicate the equipment to be taken by those coming after me.

Then on the other hand, I know that one cannot easily study alone the arts; precepts and books do not suffice; from the beginning are necessary advice and example. We have in Paris ateliers corresponding to this need; further the young student is more free. Sometimes in the paternal mansion or in a modest school must be made the first attempts; frequently the guide or temporary instructor will himself be uncertain, and the beginner will be left to the chance of some models, good or bad, procured without sequence or choice. Thus as in elementary classical books, without making the master's volume a counterpart of that for the pupil, I believe indeed that my book will be as useful to the teacher as to the pupil, and I trust that it may be regarded as a sort of Normal School book for the primary studies in architecture.

I repeat that we too frequently see badly prepared young men beginning badly with lost years; sometimes even more than lost time, all this must be unlearned and it is too late; a bad beginning hinders an entire career. Time may be saved by better preparation, and this is very important in our lengthy

studies.

Again must one face realities. In our time the architect must be a serious and educated man. The modern architect needs taste, artistic feeling, a fertile imagination, as well as knowledge, a critical sense, fertility in resources in case of programmes always more complicated. What our fethers had to solve as difficulties and requirements were nothing beside all the problems imposed on us; we must learn and know more and more. The architect today must be a very many-sided man; a scientist for all relating to construction and its applications, also a man of profound knowledge of the entire patrimony of architecture; finally an artist in the entire superiority of an art that concentrates, dominates, and associates the other arts. There is no more noble career, but there is none more arduous; nothing less than the cooperation of the most diverse faculties and the most serious preparation in the realms of thought, science and art.

I have endeavored to make myself useful in a part of this preparation by explaining what may and should be taught without restricting the freedom of later studies. For each one is the master of his choice, adviser and confidant inthe trials of composition; there is necessary the direct contact of the student and the master, daily collaboration, reciprocal and personal sympathy; where one is no longer the pupil of a school or a book, only the disciple of an artist.This instruction is full of friendship, respect and trust, is beyond every rule one of confidence, respect and friendship; the young artist receives all that may be received from others, and he will never have sufficient gratitude for his memories.

Afterward there remains for him a single judge and adviser, himself. All that may thenceforth be desired for him is to confirm the law of progress by excelling his masters.

# BOOK I. PREPARATORY STUDIES.

## Introduction to the Course in Theory of Architecture.

## CHAPTER 1. PRELIMINARY INSTRUCTION.

SUMMARY.--Necessity of preliminary studies.-- General instruction. --Scientific studies; mathematics; descriptive geometry. --Application to architecture. --Tracing shadows. --Ideas of perspective. --Drawing and modeling.

Young man, the time has come to choose a profession, and you have chosen architecture. That is well, for if that art be difficult among others, it is at least very beautiful and is particularly the useful and creative art; likewise more than any other, the art of long studies, manifold knowledge and serious thought.

Yet you are impatient and enthusiastic, I trust; you have admired our cathedrals, chateaus, court houses and city halls- and after tomorrow in your turn, you will dream of composing marvellous edifices, of placing on paper the plans of monuments, that will be symphonies of stone and marble.

Gently. --Only in novels are found spontaneous outbursts of genius, that divines everything without learning anything, excelling by mere intuition every effort and result of experience. The reality is more severe. Great artists, men of genius at their head, have always been men of extended and profound study, formed by rigorous discipline of mind, patiently identifying themselves with the elements, means and acquired patrimony of their art, advancing from the faculty of comparison to the right of choice, finally attaining to powerful originality, that glory of the artist, by superiority of knowledge, rigor in method, temper of mind, progress in love of their art, as they appreciated more and more each day its most intimate beauties.

Your studies will indeed be lengthy, they will also be more and more attractive, and if the beginning be somewhat dry, and if they must always be elevated and difficult, they will later present to you only noble and attractive difficulties.-- provided that the basis be substantial and the starting point be properly chosen. It is then necessary for you to know the plan of your studies and the stages of the route to be traveled. If frightened, there is still time to withdraw; if you

persevere, your effort will be conscious and you will have manfully merited the enjoyment reserved by the art for its faithful followers.

The architect first requires preliminary knowledge, that is not yet architecture; this will be his baggage and equipment. You have done well in your general studies in school or academy, I assume; you are an A.B., perhaps twice. All the better, for literary studies directly serve you, since later you will have to write as well as draw; indeed if they have aroused your mind, you have learned to think; your intelligence is elevated, you can read with results, reason with system, reflect and ascertain the truth of a paradox or sophism. Even if this primary basis be more or less deficient, nothing is lost, but you must yourself ensure the culture of your intelligence. Only have a sufficiently high idea of your art, to understand that the reading of a tragedy of Corneille is not without profit for the architect.

The sciences touch more directly and more visibly on architecture. Scientific studies accustom one to logic and rigor in reasoning, develop the faculty of sequence of ideas, suggest method, are the sane gymnastics of a mind desirous to analyze and verify, create the will to examine and control. Pascal denied the faculty of reasoning to one not something of a geometrician. Also practically, science will be necessary in your studies and career; its part is always secondary, for it will not give you imagination, artistic ingenuity, invention, nor taste; but without it you can but imperfectly value these qualities, realize your conceptions, nor even study them thoroughly. Since by an imperious law of progress in all concerning human life, our architecture becomes each day more scientific, you will remain behind unless you are wiser than we, who are wiser than our predecessors.

Be a mathematician as far as possible; as a minimum you require arithmetic, geometry and elementary algebra; geometry will be especially indispensable, for your art primarily treats of geometrical surfaces or solids, and it would be rash to attempt the study of architecture before possessing that science. You should also learn trigonometry, analytic geometry(curves of the second degree), statics, and if possible, elementary calculus. The latter sciences will not be indis-

pensable at the beginning of your studies and may be reserved till later. Yet since all that can be learned anywhere, it is best to complete at first all your mathematical equipment, for once familiar with the substantially concrete studies of architecture, you will rebel more against abstraction-the essence of mathematics.

You can study general physics and acquire ideas of chemistry anywhere. Learn the most of them possible, without spending too much time demanded by other studies. Fundamental principles and great laws will suffice for the present, and you will later study the specialties more directly connected with your art.

But descriptive geometry is a science to be studied in the most thorough fashion. Unfortunately it is not generally taught, usually too briefly for you. You must count much on yourself to study it with the guidance of a good treatise. This science is not really difficult for one possessing elementary geometry; it is actually merely a method of representation; but with it commences manual skill, and as line drawing nothing equals the perfect execution of the diagrams of descriptive geometry.

Understand well that everything you draw, plans, facades and sections will be descriptive geometry, often very simple, sometimes quite difficult. Certainly this science is only a century old, and the great architects formerly drew as well and as accurately. Yet they lacked only the systemayic key to the empirical methods employed by them, and their merit was only greater; to you is given this help lacking to them, profit thereby and not only study descriptive geometry, but practice it.

It is indeed a practical science, and while learning the theory, you should exercise in its application. Study no problem without accurately making the corresponding diagram with data differing from those of the diagram in your book. You thus make a personal album of descriptive geometry, and at the same time acquire the habit of accurate and precise drawing.

Accustom yourself to seize the architectural applications of the study. Descriptive geometry treats theoretically of lines, planes, cylinders, cones and spheres; it is for you to

Take examples. Thus as roofs are intersections of planes; the intersection of a prism by an oblique plane is the intersection of a chimney cap by a roof; in rustic and shafts of columns are found examples applicable to various problems in cylinders, cones and spheres; you discover surfaces of revolution in bases and capitals of columns, etc. Thus even in your walks, you will commence to see architecture, no longer as a thoughtless looker, but already with some ability for analyzing its elements and its means. The necessity for this study has been recognized, so that for several years has been required for admission to the school of Fine Arts a diagram of architectural projections as an application of descriptive geometry.

Particularly exercise yourself on graphical drawing the trace of shadows, without which you can later neither study nor render the effects of projections and the relief of your compositions.

But I consider as premature now the study of the special applications of descriptive geometry comprised under stereotomy-- stonecutting and carpentry; -for these studies are required some ideas of architecture, that you do not yet possess.

If possible, learn some first principles of perspective. This is not urgent yet, and besides, perspective is easily learned with a thorough knowledge of descriptive geometry and of architectural forms; yet it is not truly possible to design without the first ideas of perspective.

Nor they speak to you of literature, history, sciences-- and drawing, I do not forget these, but have desired to inscribe first in you the most serious of your studies, wishing you to know that the right to artistic studies is a reward that must be merited.

But one thing is to be said of drawing, that you will never be too much of a draftsman. Study drawing in a serious and severe fashion, not to make pleasing sketches, but to accurately take a form and an outline; learn to see your model and to faithfully render it, whatever it may be; be a loyal draftsman, rather than you imagine. Only the study of drawing will make you perceive proportions, those extremely delicate shades that defy the compasses and yet are perceived by the eye; it will give you fertility, imagination and artistic find examples. Thus on roofs are intersections of planes; the intersection of a prism by an oblique plane is the inter section of a chimney cap by a roof; on vaults and shafts of columns are found examples applicable to various problems on cylinders, cones and spheres; you discover surfaces of revolution on bases and capitals of columns, etc. Thus even in your walks, you will commence to see architecture, no longer as a thoughtless looker, but already with some ability for analyzing its elements and its means. The necessity for this study has been recognized, so that for several years has been required for admission to the School of Fine Arts a diagram of architectural projections as an application of descriptive geometry.

Particularly exercise yourself on problems showing the trace of shadows, without which you can later neither study nor render the effects of projections and the relief of your compositions.

But I consider as premature now the study of the special applications of descriptive geometry comprised under stereotomy--stonecutting and carpentry; --for these studies are required some ideas of architecture, that you do not yet possess.

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But one thing is to be said of drawing, that you will never be too much of a draftsman. Study drawing in a serious and severe fashion, not to make pleasing sketches, but to accurately make a form and an outline; learn to know your model and to faithfully render it, whatever it may be; be a loyal draftsman, rarer than you suppose. Only the study of drawing will make you perceive proportions, those extremely delicate shades that defy the compasses and yet are perceived by the eye; it will give you fertility, imagination and artistic

wealth. This is so true, that we always see the most skilful draftsman become the most fertile designer, most endowed with imagination and ingenuity, both for conceiving the arrangement of a plan and for projecting an ornamental facade, and this should be so, for in art all things are connected and drawing is the corner stone of all the arts.

You will never draw architecture well or execute well a geometrical drawing, unless you are sufficiently a draftsman in the usual sense of the word. Do you desire proof of this? Assume that two architects measure the same architectural motive, purely geometrical and without sculptures. Both have the same accuracy in their measurements and sketches, but one is a draftsman and the other is not. The drawing by the former will be faithful and correct as a representation of the model, while that of the second will render neither its character nor even its form.

The study of drawing is completed by that of modeling, another form of drawing; for in drawing or modeling not the hand is trained but the eye, the faculty of observing correctly; only while drawing teaches you to see the appearance of objects, modeling teaches you to observe their reality, and more directly prepares you for the sense of architecture.

As for geometrical or architectural drawing, I will speak of it later.

Such is the entirety of the plan of preliminary studies, that can be made anywhere that secondary instruction is given. Aspecial school is unnecessary, and it is better to not attempt the study of architecture until well prepared by these preliminary studies. Then wifh the mind ready for the method regulating your later studies, you will be equally interested in their artistic and scientific sides, and will make rapid progress, for you will have no bad habits to lose, nor defective beginnings to forget; marching straight from the starting point and continuing in a straight line, it suffices for you to march forward.

## CHAPTER 2. DRAWING INSTRUMENTS AND THEIR USE.

Contents. --Drawing instruments. --Practical suggestions.--Drawing paper. --Use of board, T-square, triangles, dividers etc. --Lines. --Chinese ink. --Practice of washes.

Some words at first relating to your equipment.

You will require two drawing boards, for grand eagle paper (30 X 42 ins.) and a half grand eagle (21 X 30 ins.). You may also have a quarter grand eagle 15 X 21½ ins.). These boards should be panelled, i.e., with frame of hard wood and panel of soft wood; boards with hard wood cleats at the ends only are not sufficiently accurate. The best woods are [illegible] for the frame and poplar for the panel. There should be no knots to spoil the wood, which should have straight grain, be well fitted and truly plane.

Protect your boards from accidents, sun and dampness, everything that might warp them, and when the edges are not straight have them trued, or you will no longer have parallels in your drawings.

You will need grand eagle, half grand eagle and quarter grand eagle T-squares of pearwood with straight grain and uniform texture. Avoid injuring and never use a T-square to guide or cut off paper. The blade must remain perfectly straight without notches or nicks.

Two triangles at 30 and 45 degrees. Good triangles are made of wood, hard rubber or celluloid; wood should be selected as for the T-squares. They must not be too thin, about the same as the blade of the T-square. The triangles must retain their accuracy are framed. (Fig. 1). This equipment is completed by a folding metre rule and a boxwood scale 2 decimetres long (7.87 ins.), graduated in millimetres. Division in half millimetres is useless and troublesome.

The case of dividers should be well chosen, for which the price must be paid, for good instruments last a lifetime and make your work easy. Do not encumber yourself with a large, heavy and troublesome box, for the pocket case is easy, light and portable. (Fig. 2.).

You find therein dividers with plain points for measuring, dividing, etc. --Dividers for circles with jointed points for drawing circles, --Pen and pencil points fitting these divi-

## CHAPTER 2. DRAWING INSTRUMENTS ABD THEIR USE.

SUMMARY. --Working instruments. --Practical suggestions.--Drawing paper. --Use of board, T-square, triangles, dividers etc. --Lines. --Chinese ink. --Practice of washes.

Some words at first relating to your equipment.

You will require two drawing boards, for grand eagle paper (36 X 25 ins.) and a half grand eagle (25 X 18 ins.). You may also have a quarter grand eagle( 18 × 12.5 ins.). These boards should be paneled, i.e., with frame of hard wood and panel of soft wood; boards with hard wood cleats at the ends only are not sufficiently accurate. The best woods are rock elm for the frame and poplar foe the panel. There should be no knots to spring the wood, which should have straight grain, be well fitted and truly plane.

Protect your boards from accidents, sun and dampness, everything that might warp them, and when the edges are not straight, have them trued, or you will no longer have parallels in your drawings.

You will have grand eagle, half grand eagle and quarter grand eagle T-squares of pearwood with straight grain and uniform texture. Avoid injuries and never use a T-square to glue or cut off paper. The blade must remain perfectly straight without notches or nicks.

Two triangles at 30 and 45 degrees. Good triangles are now of wood, hard rubber or ebonite; wood should be selected as for the T-squares. They must not be too thin, about the same as the blade of the T-square. The triangles best retaining their accuracy are framed. (Fig. 1). This equipment is completed by a folding metre rule and a boxwood scale 2 decimetres long (6.55 ins.), graduated in millimetres. Division in half millimetres is useless and troublesome.

The case of dividers should be well chosen, for which the price must be paid, for good instruments last a lifetime and make your work easy. Do not encumber yourself with a large, heavy and troublesome box, for the pocket case is best, light and portable. (Fig.2.).

You find therein dividers with plain points for measuring, dividing, etc. --Dividers for circles with jointed points for drawing circles. --Pen and pencil points fitting these dici-

ders. --Spring dividers for drawing very small circles. --Extension bar for the large dividers. --Two ruling pens. --Key for adjusting divider heads, not too tight or too loose.

These instruments are made in brass or white metal, which are equally good.

Take proper care of your instruments, never allowing ink to dry in the pens.

Pencils are to be used, crayons or lead pencils, which are to be of good quality, for example Faber's, of which there are four numbers:--1, very soft; 2, soft, 3, rather hard; 4, very hard. Use either kind according to the case, always lightly and not creasing the paper. Thus No.4 is excellent for drawing the axes, very precise limited lines; No. 2 and No.1 are rather for sketching in free hand.

You will have some porcelain cups, a stick of Chinese ink, that to be good must be hard, shining, black or slightly reddish and not blueish, producing neither grains nor sediment; two brushes of medium size, retaining good points when wet, set in the ends of a single handle; drawing pens with light holders of same size as pencils; mouth glue; soft elastic rubber, not hard gray or scratching, and a soft sponge.

For colors, sticks of carmine and of Prussian blue suffice to tint parts in section. But I strongly advise no box of colors at present. You cannot believe how daubing produces bad habits, when one does not know how to wash in a drawing, and prevents the acquisition of the prime qualities of drawing, clearness and relief.

Several sorts of paper are necessary. For drawings left in pencil, sketches, etc., yellow or rose Bulle paper is excellent and very cheap, but must not be rubbed too much or be too soft. Never use ribbed paper, which interferes with line drawings. For washes, there is only English Whatman paper, excellent except for its high price. For sketching, Canson, Bulle or quadrille paper, for tracing paper buy dioptric. Kee paper dry and protected from dust.

The use of this equipment requires some advice for forming good habits from the beginning.

First adjust to your height the drawing table and the slope of the board. Whether seated or standing, avoid bending over and especially depression of the chest injurious to health, especially if growth be not completed. For a delicate youth, the family physician should control the arrangement. Always, the drawing board should not be horizontal, and one should bend as little as possible to reach it. Adjustable trestles are therefore excellent. (Fig. 5).

Always remove traces of the former glued edges; by wetting and soaking them, they can be removed by a blade that scrapes and does not cut, wash well the board and glue on a new sheet only after it is well dried. To glue the sheet, wet it uniformly on the back so as to remain flat, remove water with a sponge or dry cloth, so that the sheet may be uniformly damp and expanded but not wet. Then glue it all round by beginning at the four middles, stretching it properly, then the corners and lastly the intermediate parts. Thus the sheet is properly and regularly stretched, and your drawing will not be deformed in cutting it off. Wait until the sheet is perfectly dry.

The T-square serves to draw horizontals and as a base for the triangle for verticals. Only use it with the head guided by your left hand. For verticals, apply the triangle on the T-square, [illegible] to be in front and a little to the left. Top light is wanted for architectural drawing. The square and triangles should always be very clean. Your pencils are finely pointed and lightly used, held as nearly vertical as possible. When it lies along the T-square or triangle the lines vary and may not be straight. Remember that pencil lines are working lines to be removed without using the rubber much or injuring the paper. If the pencil lines are to be inked, they should be light, for ink adheres badly to a heavy pencil line.

To sharpen a pencil [illegible], a fine file or sandpaper is useful.

Divider points should rest lightly and not make holes in the paper. Keep the leg perpendicular to the paper; if ordinary, [illegible]. Similarly for the dividers for circles; the joints are bent to keep the point, pencil and pen perpendicular to the drawing. [illegible]

The ruling pen is held like the pencil, lightly and as vertical as possible, steadying the hand on the paper, it is especially if growth be not completed. For a delicate youth, the family physician should control the arrangement. Always, the drawing board should not be horizontal, and one should bend as little as possible in using it. Adjustable trestles are therefore excellent. (Fig. 3).

Always remove traces of the former glued edges; by wetting and soaking them, they can be removed by a blade that scrapes and does not cut, wash well the board and glue on a new sheett only after it is well dried. To glue the sheet, wet it uniformly on the back so as to remain flat, remove water with a sponge or dry cloth, so that the sheet may be uniformly damp and expanded but not wet. Then glue it all round by beginning at the four middles, stretching it properly, then the corners and lastly the intermediate parts. Thus the sheet is properly and rapidly stretched, and your drawing will not be deformed in cutting it off. Wait until the sheet is perfectly dry.

The T-square serves to draw horizontals and as base for the triangle for verticals. Only use it with the head moved by your left hand. For verticals, slip the triangle on the T-square, its vertical side being at the left. Then the light must be in front and a little to the left. Top light is very bad for architectural drawing. The square and triangles should always be very clean. Your pencils are finely pointed and lightly used, held as nearly vertical as possible. When it lies along the T-square or triangle the lines vary and may not be straight. Remember that pencil lines are working lines to be erased without using the rubber hard to injure the paper. If the pencil lines are to be inked, they should be light, for ink adheres badly to a heavy pencil line.

To repoint a pencil when not requiring to be recut, a very fine file or sandpaper is useful.

Divider points should rest lightly and not make holes in the paper. Keep the leg perpendicular to the paper; if oblique, inaccuracy and injury to the paper are produced. Similarly for the dividers for circles; the joints are bent to keep the point, pencil and pen perpendicular to the drawing. Hence dividers without joints in legs are worthless.

The ruling pen is used like the pencil, lightly and as vertical as possible. Pressing too hard on the paper, it is pressed, or too hard against the edge, you close the pen unconsciously. The ink must always be fluid in the pen, frequently renewed, and the points cleaned with water and a rag. The same for the free hand pen. Never use ruling or sketching pens with writing ink.

The ruling and free hand pens produce the definite drawing, after which the pencil lines are erased. You will soon make only the essential lines with the pencil, many lines on a drawing being made directly in ink between the limiting pencil lines; the intelligence of the craftsman will apply this method to each drawing; it is useless to first make the entire drawing in pencil and go over it again in ink, a purely [illegible], only fatiguing the draftsman and wearing the paper.

[illegible] ink must be rubbed in a perfectly clean cup; never [illegible] in the cup. Special care must be given to the use of Chinese ink.

Drawing ink must be black but not pasty; be renewed several times daily, especially in summer; the cup is covered to avoid dust.

[illegible] in the cup ink till sufficiently black, leave it in the covered cup to settle. Then take from its surface with a brush what is necessary for the wash, not disturbing the bottom, diluting this in another cup with more or less water. Thus never pass over a wash with the ink in the first cup in which it was ground. When the wash is well mixed with water in the second cup, avoid stirring it when dipping the brush, having sufficient tint without reaching the bottom, where the deposit from even the best ink should never be used for the work.

For washes of small extent, a bit of [illegible] may be used instead of a cup.

Skill in washes only comes from practice, yet some advice is useful. If in spite of every care for clearness, your paper is no longer white and seems slightly soiled, wash it lightly with a very soft sponge and perfectly clean water, but very lightly and passing it everywhere. Then dry it with a sponge as lightly as possible and without rubbing, which might efface a part [illegible] creased, or too hard against the edge, you close the pen unconsciously. The ink must always be fluid in the pen, frequently renewed, and the points cleaned with water and a rag. The same for the free hand pen. Never use ruling or sketching pens with writing ink.

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Chinese ink must be rubbed in a strictly clean cup; never rub again ink dried in the cup. Special care must be given to the use of Chinese ink.

Drawing ink must be black but not pasty; be renewed several times daily, especially in summer; the cup is covered to avoid dust.

Similar care is required for washes. After rubbing in the cup ink till sufficiently black, leave it in the covered cup to settle. Then take from its surface with a brush what is necessary for the wash, not disturbing the bottom, diluting this in another cup with more or less water. Thus never pass over a wash with the ink in the first cup in which it was ground. When the wash is well mixed with water in the second cup, avoid stirring it when dipping the brush, having sufficient tint without reaching the bottom, where the deposit from even the best ink should never be used for the work.

For washes of small extent, a bit of non-absorbent paper may be used instead of a cup.

Skill in washes only comes from practice, yet some advice is useful. If in spite of every care for clearness, your paper is no longer white and seems slightly soiled, wash it lightly with a very soft sponge and perfectly clean water, but very lightly and wetting it everywhere. Then dry it with a sponge as lightly as possible and without rubbing, which might efface a part. You can begin with the wash when the sheet is no longer wet but damp, which will be best for the first

wash.

This care seems trifling, but it is very easy, and a transparent wash is thereby obtainedwith uniform tint and without spots, which produces the charm of neat and fresh shading in relief.

The use of the brush comprises personal skill acquired by use; your work must always remain wet where you have to extend it; a wash that dries too quickly and irregularly is the danger for the beginner. The board must be slightly inclined in the direction for passing the wash, which is to be kept straight across, carrying it down 3/8 or 3/4 inch at a time, but commencing back two or three inches. The brush thus passes everywhere several times, and you will see the wash dry gradually from the top, keeping parallel to your work and not gaining on it. Leave the sides a little behind, and the wash will run toward the middle, avoiding dark streaks at the edges.

In brief, the wash must be so passed that the paper is thoroughly and uniformly wetted.

For graduated washes, whether from black to white or from white to black, make this graduation continuous, modifying tha wash by adding water or black at each advance, seeing that these additions are well proportioned. It is very difficult to succeed with a well graduated wash on paper still white; much better to pass a flat wash to serve as a basis for the graduated tint.

The brush requires great lightness of hand. A matter of habit and also of good habits. The right arm should not support the body, nor should it rest on the drawing; the little finger of the right hand alone is in contact with the paper. The brush is held nearly like a pencil by thumb, fore and middle fingers, should be free in its movements and merely touch the paper with the point and not with its body. Always take up equal quantities of the wash, if too much, remove this, and when reaching the end of the wash, dry the brush gradually by touching it to blotting paper. Leave the board inclined while the paper is not dry. If a second wash is to be passed over the first, be certain that it is no longer damp, or all will be lost.

Avoid passing a large number of washes successively over the same place, or the paper will become hollowed by the

tension of the dried and stretched parts.

The sponge may soften too dark washes and remove streaks; but this remedy must not be abused. When sponging, use much water, very lightly and patiently; the water must be very clean, and commence by wetting fully the rest of the paper before wetting the washed portion. Otherwise thw sponge removes a portion of the wash and distributes it over the white paper, soiling that. After sponging, carefully remove the water, constantly washing out the sponge in clean water.

But first of all, never forget that the primary quality of a wash is clearness. You can draw with a brush as clearly and precisely as with a pencil. To acquire this accuracy and avoid errors practice is necessary; you will not succeed at the first attempt, but if not discouraged, you will soon use the brush with skill and freedom.

A final advice to beginners. One is proud of having finished his first wash drawing and hastens to cut it off. Even if the washes are no longer wet, the paper is not yet dry in its fibres, and the drawing warps if cut off too soon. Wait at least a day before removing a drawing.

## Chapter 3. ARCHITECTURAL DRAWING.

SUMMARY. --Geometrical drawing. -- Its requirements. -- Scales. -- Plan. -- Section. -- Elevation. -- Necessity of several projections for a complete representation. --Axes. --Drawing by axes; examples. -- Verticals and projections. -- Lines limiting contours. -- Oblique projections. -- Developments.

Sketches. -- Method to follow. -- Sketches from memory. -- Selection of sketches.

Architectural drawing is geometrical drawing, accurate drawing, and may be termed drawing in particular. While picturesque drawing represents only the appearance of objects, geometrical drawing represents them as they are. For example, Fig. 4 shows a capital in perspective and Fig. 5 is the same capital in geometrical drawing. This method alone permits the ~~most~~ exact realization of a conception or the accurate reproduction of anything already realized. Thus it is imposed on all the arts and industries, that live by creations, whether of machines or jewelry, artillery or furniture, construction or decoration, fortifications or architecture.

Its primary quality is then absolute accuracy. No care for obtaining this accuracy is excessive, for in spite of this, the drawing and ideal precision will always differ by a mathe matical line. The entire method in geometrical drawing then consists in avoiding all chances of error, even when merely copying a drawing at the same or a different scale, the logical procedure is far from being unimportant. It is not less important for the benefit from the study that assures the execution of a drawing, unless it be merely a mechanical work.

The first principle for making the drawing a work of intelligence as well as an exercise of the eye and hand is to identify one's self with the model, to reproduce in your turn and by the same means the work of the original draftsman. In copying a drawing, seek the mode of procedure of the original designer and proceed in the same manner; if translating an actual work of architecture into a drawing, seek how its author must have drawn it to ensure its execution, and proceed likewise.

What are the means for this? The different projections com-

bined in plans, sections and elevations. Note this order, for it is the logical one. These drawings are laid out by scales, a ratio adopted between the object and the drawing.

The most simple scales are to be preferred; one or ten centimetres per metre (1/100 or 1/10 full size). Purely decimal ratios do not lead to errors. But material reasons may require other scales, which will generally be twice or half the former; thus 1/2 or 2 centimetres, 5 or 20 centimetres per metre (1/200, 1/50, 1/20 or 1/5 full size).

The plan is a section of an edifice at a variable height made by a horizontal plane intersecting walls, piers, partitions, etc. Assume this plan at a proper height to show all the details of construction, walls, doors and windows, piers, columns or pilasters, fireplaces etc. It may be regarded as a flat imprint taken from the structure at a uniform height. %ig. 6 represents a part of the construction above the grounds which is shown in plan by Fig. 7.

On the assumed plan the construction is shown by its horizontal sections, an invariable element, but on it may be projected anything below or above this. In the first place the plan shows those architectural parts projecting beyond the bases of the walls or piers, such as base mouldings, plinths, steps etc. Or in the second case are shown the vaults or ceilings, entablatures or cornices. Both projections, or half of each are given, when both above and below are of interest.

The section is an intersection of an edifice or its part by a vertical plane; it is vertically what the plan is horizontally. And likewise it first shows the intersections of the assumed plan with the construction. These outlines comprise the parts in section. Then as on the plan may be projected all that might indeed be projected on it in the building.

This shows that a single section is rarely sufficient to take into account the entire interior of an edifice, and at least two are generally necessary. One is in a plane perpendicular to the facade and is the longitudinal section; the other is parallel to the facade and is the transverse section. Numerous secondary sections are also frequently necessary.

A section limited to a facade wall for use in the study of the elevation is rather termed a profile.

The elevation is the projection of the edifice on an

external vertical plane. It may comprise parts very far separated, for example, the principal facade of a church and farther back the transepts.

Except in case of uniform architecture everywhere, several elevations are necessary for taking into account the exterior of the edifice; principal, side and rear facades.

Here is an example of plan, section and also elevations for a complete building, the Arch of Titus at Rome. (Fig. 8).

You observe that no less than four drawings are required to represent this very simple monument.

The plan is taken at a height sufficient to show the columns in section, exhibiting on one half the plinths, pedestals, bases etc., and on the other the vaults and entablatures. A single side facade suffices, both being alike, and a rear facade would be useless because repeating the principal facade. But the side facade is necessary for it does not result from the other drawings. The longitudinal section also suffices, for its elements with those of the facades determine everything Evidently after the composition of the edifice, one can see how many drawings or projections are necessary and which are most useful.

DRAWING BY AXES. -- The word axis will frequently reappear in your studies; it is the key of drawing and of composition, so that it is to be properly defined.

You know a geometrical axis, which is merely on the line dividing into two equal parts a symmetrical plane figure, or the line joining the poles in a surface of revolutionor a regular solid, like a right prism with regular bases. The idea of the axis in architecture is more extended, for it comprises the entire vertical plane separating the two halves of a symmetrical edifice. Thus although its graphical representation is a right line, remember that it is not a mere line. For example, take a church; in showing its plan, its axis will be the straight line bisecting the outline of the plan, yet this line is only the projection of the middle plane forming the axis of the entire monument, and the keystones of the vaults, the chandeliers supported bythem, the centre of the great rose window or of the apsidal window, are on the axis of the church. Note further that the axis of the plan, the axis of your principal or rear facade, and that of the longitudinal

section, are only traces on these drawings of the same vertical plane, which is the principal axis.

But there are others; parallel to the former are the axes of the side aisles and the axes of the piers between them. Transversely are the axes of the transepts, of each bay, then the radial axes of the chapels etc.

If the plan of this church is to be drawn, by locating first these various axes very precisely, you will succeed in constructing the plan. Also by placing the axes with care and verifying them, chances of errors are minimized.

Thus on an architectural drawing it is necessary to first begin with the axes.

This method of capital importance will be explained by some examples. Commence by drawing a plan, assumed to be that of the beautiful vestibule of the Mint at Paris. (Fig. 9).

After drawing axis 1 as the principal axis of the monument, you note that the five aisles of the middle pavilion are equal. Then by first locating the outer axes 2, and bisecting, the intermediate axes 3 are obtained. Thus the chance of error is lessened, but would be doubled if you locate axes 1, 3, 2,. Passing to the side, you place the outer axes 4 and then 5, bisecting the space 4 to 5 to obtain axis 6. These are the principal axes of the aisles.

Next come the axes 7 of the rows of columns, arranging them with reference to the axes 3; finally the axes 8 with reference to the outer axes 7, controlling them by the axes 2.

Similarly lengthwise, locating first axis 1, then the outer axes 2; bisecting to find 3, and laying off on each side of 3 the half distance, the axes 5 and 6 of the columns are found. Secondary axes are located by the same method.

Finally, it is well to test the different operations by verifying the equality of distances of the symmetrical secondary axes from the central axis, and in general by operations differing from those employed in placing them.

By studying this plan and the manner of laying it out, it is evidently more accurate, and the arrangement of the axes is far from unimportant. This exercises the intelligence of the draftsman.

On this point, I may say that it is more difficult to draw a

plan properly than is supposed, perhaps more than anything else. Accuracy in plans is imperative, and to familiarize yourself with architectural drawing, you will do well to first practice drawing plans.

Pass to sections. -- Taking the same example of the Mint, you see readily that the architect could fully study his composition by the aid of numerous sections. Two are particularly necessary, the two on the principal axes of symmetry, crosswise and lengthwise.

If both are to be drawn, first examine which determines or controls the other. You see that in this case it is the transverse section(parallel to the facade). The longitudinal section is merely the projection of the other. Then commence with the transverse section (Fig. 10).

First locate the axes as on the plan, 1, 2, 3, 7, and 8; then verifying them, Thus is unity of method used in the drawings of plan and sections.

As for the profiles of parts in section,first determine the heights of the essential elements. Taking the floor A as a starting point, locate first the upper line B of the capitals of the columns, and then the centres of the vaults C and

Then using these controlling lines, you draw the details successively. Thus for the columns locate heights of bases from the floor A; the heights of the capitals and architraves with relation to your line B. Evidently if all these heights were set off from the floor A the least error would sensibly deform your capitals, while the total height AB of the column being once determined, you can err but little in the small height of the base or that of the capital, and even admitting a slight error, this will not be observed with regard to the length of the shaft of the column. You should thus control the heights by verifications, that are always possible.

These indications suffice to exhibit the method; you must apply it, and there is no need of stating how you should draw the longitudinal section.

ELEVATIONS. --In the preceding the drawing may proceed with axes, even for parts in elevation. But on an elevation it is not always so, for some profiles in section or elevation must be traced from conventional plumb lines. For example,

take a fragment of the Doric order from the Parthenon (Fig.11).

To reproduce this drawing, the projections must be measured from a single vertical. The axis of the column is not a logical starting point, for it determines nothing but the column. It is better to proceed as the author of the drawing must have done, who employed a plumb line on the exterior and measured the distances from that line. But this plumb line only serves for the profile and to locate the axis of the column; then you draw by axes all that this method comprises; thus you place the axis A of the column, B of the triglyphs, C of the metopes, D of the lion's head etc. For the heights, first lay off the large divisions, the entire capital, entire frieze and cornice; then refer each detail in height to these primary divisions.

The channels of the triglyphs and the drops are to be traced according to their respective axes. As for the flutes of the column, which can only be drawn by the aid of two projections, do not copy them, but project from the plan, dividing its circumference into twenty parts.

First study your model thoroughly. Thus in the proposed example, a careful examination shows that the architrave is slightly inclined, but not the frieze. If you have a chance to see a cast of what you draw, either similar or actually so, do not fail to study it. I cannot too frequently repeat, that architectural drawing must not be limited to an exercise of the hand, but must be a real study of what you draw.

LIMITING LINES. --You know the abscissas and ordinates of geometry. For all parts of a drawing whose elements are not geometrical lines such as the straight line or circle, the method of abscissas and ordinates is required for a profile, a series of carved ornaments, such as eggs etc. But it should be well chosen. For example, take a very simple example of a baluster (Fig. 12). It is evidently drawn by reference to its axis by locating general divisions, A-B(plinth), B-C(base or scotia), C-D(shaft), D-E(cap), after which you place the secondary lines of the mouldings. But between C and D, for example, the profile of the shaft may vary much, and it can only be drawn by horizontals. Instead of taking arbitrary lines, draw the limiting line of the width m-m, mark its location M and transfer this operation to your drawing;

similarly for the line n-n and the points N, which gives the least diameter. Do not mark these points by a mere pencil dot, but trace your limiting lines everywhere and erase them only after inking. These lines will guide and give accuracy in drawing.

Take another example, afragment of a cornice with various ornaments, taken from the Temple of Concord at Rome(Fig. 13). The working lines marked on this drawing, and which must be preserved in pencil until completion of the drawing, will sufficiently indicate the method to be followed, without repeating my explanation.

In brief, architectural drawing is to be entirely accurate and requires a thoughtful method and systematic habits. Drawing gains everything, including facility. But the method can only be general; the intelligence of the draftsman in applying it will always recognize the advance from principal to secondary. Again, this is merely the mechanism of drawing, to which must be added taste, refinement and feeling, for that is only one precept; only by hammering can one become a smith.

OBLIQUE PROJECTIONS. --It frequently occurs that on a facade or section, architectural motivesare oblique to the principal plane of projection. Thus on a circular edifice a series of similar windows project on the facade at different angles, consequently having different widths, but their heights do not vary.

Familiarize yourself with these conditions that may frequently occur. Here descriptive geometry will be precious, for all that concerns changes in planes of projection, recesses and developments.

With a small difficulty is also found a great benefit. To properly project a motive at any angle it must be known and analyzed thoroughly, and an architectural arrangement drawn in normal projection only gives up its secrets when drawn in oblique projection.

Then as a very useful exercise, I advise you to supplement your normal by oblique projections, a good exercise in drawing and a particularly excellent preparation for architecture; forced to analyze your models, this study compels you to see in space, note the projections and see the position of details. You work on the reality and no longer on the image; soon

you will see the utility of this exercise.

I give here as an example one of the windows of the second story of Palace Farnese at Rome, projected normally and then at an angle (Fig. 14). Evidently only the normal projection permits the study of proportions, and that in oblique projection shows better to a beginner the composition of that window, its projections etc.

Likewise translate projections into developments or inversely, especially for drawings of vaults. Evidently the decoration of a cylindrical vault, a hood, or a circular wall, concave or convex, can only be studied on a development; but on the entirety of a drawing even this decoration appears in projection. Thus for example, is a drawing representing a bay of the loggias of Raphael at the Vatican (Fig. 15,). The arches in section are represented in projection and elsewhere in development, while the vault is shown in development.

In brief, study architectural drawing like architects; Become accustomed to see in the drawing the object drawn; the representation must soon become for you merely a language, and you actually see the thing, just as with the composer of music, while jotting down on ruled paper his written composition, he actually hears it; just as in reading in a book with printed letters, you no longer see the material signs in lending yourself to the emotion of the understood words.

## SKETCHES.

All the preceding treats of accurate drawings, measured and made on the board with square and compasses. The part of intelligence in these drawings has been fully shown. But you will also draw otherwise in sketches, where you owe nothing except to yourself.

The sketch will be the most rapid means of progress in your art, for you cannot sketch without having carefully examined and analyzed the object, nor render it without intelligence and knowledge of the subject. Not only must you seize the composition, distinguish its elements, but must fix its proportions without aid except a careful study of those proportions. Neither compasses nor rules, the eye alone being the sole instrument of measure and of estimating proportions.

Nothing is more charming and attractive than the sketch, but the habit is not improvised, for much must be done before

attaining freshness and certainty; practice alone serves, but I may at least give some advice concerning the method and the choice of useful sketches.

First never make a sketch for a collection of materials, but for the benefit derived and to teach you to see. You may preserve sketchbooks as souvenirs of your studies, but the benefit is the same for your instruction if your sketches disappear; every completed sketch has rendered all its service.

Make them from the reality to teach you to see, and not from representations, but as required by your model with plans, sections and elevations, not for showing to others, but to ensure your thorough study. Reject measures in order to make your eye an accurate instrument.

Your sketches should be geometrical, accustoming you to see geometrically, even if located obliquely, for example, if you wish to draw the upper entablature of an edifice.

Later make sketches in perspective, but only when having the assured habit of the geometrical. Perspective sketches only supplement those in geometrical forms.

At first you will do well to use squared paper, that facilitates accuracy, but as soon as you can free yourself from that guidance, use only plain paper.

A sketch should be light and clear, with shading only to express relief, but without black or rendering, drawing being first of all.

Finally if courageous, I cannot too strongly advise sketching from memory as an excellent exercise. Observe your model as closely as possible, return home and attempt to sketch it. Your memory will betray you and be imperfect. Observe it again more carefully, twice or thrice if necessary, and you will finally make a sketch as correct as if you went to compare it.

I present here an example of a sketch on squared paper, the motive being an architectural fragment from the Hall of Caryatids at the Louvre (Fig. 16).

So that this work be truly useful to you, it is necessary to pursue your studies and apply yourself; or rather your studies will be doubled in part; outside before the reality the sketching of objects as identical as possible, at any rate similar. Never exaggerate your ambition and do not at fir

attempt a sketch of the facade of a cathedral or palace. But I assume that you will draw an entablature, and then you may find at hand a similar entablature, which forms your sketch.

If you are in an atelier and are present at the studies of your comrades and the lessons of the master, you will see and hear many things, that will be a dead letter to you. But examples exist and can be pointed out to you; see them and you will understand before them the misunderstood lesson; again a subject for your sketch.

You will later be able to compose for yourself and to study at first the elements and later the varieties. Consult your books and you will receive advice for the school or atelier. But the book of reality is always there to instruct you and confirm these instructions by the best examples and the superior truth of what exists. I say again, there are your sketches.

I then ask of you to parallel the study in the atelier and of the reality by the drawing board and the sketchbook. This method is fertile, and if you pursue it, you will be surprised by the charm of your progress. But will is necessary and many lack it. Workers even devote themselves fully and patiently to the indicated task or lesson without aiding the personal work of thoughtful initiative; idleness of mind and lack of will. Never neglect this powerful means of progress, and if you do not see results at omce, be confident and you will soon congratulate yourself on it.[1]

(Note 1. I am so convinced of the importance of this method, that having to propose for the course in Theory of Architecture at the School of Fine Arts the use of an annual gift, I have asked that this encouragement be assigned to the most intelligent collection of sketches made of the actual objects treated in the course.)

## Chapter 4. Shading in General and Washes.

SUMMARY. -- Shading in relief. --Shadows at 45°. --Shadow and light. --Values. -- Cast shadows, shades and reflections. -- Shading of parts in the light; shadows. -- Examples. -- Rendering distances.

The drawing is only complete if on the drawing be placed the shading, i.e., the expression of the form. Any mode of shading is good if it be correct. The wash is the most common procedure for shading an architectural drawing; but the methods of shading are the same, whether with wash or rendered with the pen, crayon or by mixed means.

Shading has no absolute rules and all means are good, if the effect be produced, reliefs and forms being represented.

Yet some general principles can and should guide in shading a drawing.

SHADOWS AT 45°. -- It is an invariable custom to assume the luminous rays, whose horizontal and vertical projections make angles of 45° with the ground line, the actual direction of the light being that of the diagonal of a cube with sides parallel and perpendicular to the two planes of projection.

This has two advantages, the outlining is easier, which is to be considered, the tracing of the shadows being often lengthy and complicated, for the widths of shadows equal the projections; consequently the width of the shadows indicates the relief of one part with reference to another.

Tracing shadows is frequently difficult, and it is one of the essential parts of descriptive geometry, that you will further find in special treatises (Particularly M. Pillet's Trace des Ombres). As for indications beyond drawing, such as shadows of ornamental parts, a feeling for projections will permit giving them a true value by intelligent indications, a result of acquired experience.

VALUES. --After tracing the shadows, pass everywhere the shade wash, for your washes consist of shadows and lights.

As a first principle remains that distinction of shadow and light; shadows are graduated as well as lights, but one must distinguish between shadows and lights. In the same drawing-- unless with great distances between the different planes -- the darkest lights must be less dark than the shadows most lightened by reflections.

On the other hand, geometrical drawing not having the illusions of perspective to show distances and projections, is restricted to a more expressive shading, since only the values of tints indicate distances.

Thus to make a plane advance or recede in reference to another, the only means will be to tint it differently. Observe what occurs in this respect in nature; while an object placed near your eyes is vividly shaded, a distant object is much less so, and at the limit of the horizon is seen only a mass without details, confused in a uniform gray. Thus the nearer the object, the more it ids shaded and the greater the difference between shadows and lights; on the contrary at the greater distances the shadows and lights tend more to become confused. Then as a principle, you will have on the first plane vigorous shadows and bright lights; between these are intermediate proportions of shadows and lights. And these effects are real at great distances, and are to be observed when it is necessary to make visible several planes, but in what proportion? There is a question of degree and of skill.

So I summarize the rule of values for the different planes in this principle, --for example when on a façade are projections and recessions,-- that in the distance is little shading, but as you approach the first plane, the shading is to be more and more accented.

What will be this shading? twofold, shading of shadows and shading of lights; this is conventional to a great extent, but I shall endeavor to keep closely to nature.

First by looking closely you will see no flat tints in nature, but every light and shadow is shaded, i.e., degraded; the shadows more sensibly than the lights. The shadows are modified by the reflections, i.e., by the indirect lights cast on the shaded object by the vicinity of other lighted objects.

Assuming a cylindrical body like the shaft of a column, cast shadows and only actual shadows may be seen on the cylinder. Cast shadows result from interception of light rays by another solid, when without this the cylinder would have been lighted; actual shadows result from the absence of light on the part of the cylinder, that by its position cannot receive the luminous rays.

Naturally, cast shadows have less reflections. Indeed the bending of light producing reflections comes from lighted [illegible] greatly in shadow, but which in theory can only be regarded as secondary sources of luminous rays, whose resultant will be parallel to the light rays, but with the inverse direction. In certain respects it may be said, that the phenomena of reflections and of visibility are identical. Thus while the light has a direction of 45° downward from left to right [illegible], the direction of the reflections will be upward and from right to left.

This theoretical convention is too absolute but is necessary, and will be the rule for your shading. Commence with the lights, where the tints are more easily understood.

Assume a solid in white stone, for example a sphere (Fig. 17). It is easily seen that the brightest lighting acts at the point of intersection of the surface by the luminous ray passing through the center, [illegible] this pole of light; the angles of the luminous rays with the surface constantly diminish in parallel zones with the luminous point as their pole, until they become tangent to the sphere in a great circle, having the luminous point as pole, and which is the line separating the shadow and the light. The light thus diminishes from the pole to the equator.

The reverse takes place in the shadow, for the darkest reflection will be at the other end of the diameter passing through the luminous point, and the shadow diminishes in intensity from the circle separating the shadow and light to that pole of reflections.

But if any body casts a shadow on the lighted portion of the sphere, that cast shadow will have less direct reflections and is therefore more intense than the shadow of the sphere, and the more intense, since it falls on a more directly lighted part of the sphere.

Therefore the rules for shading: a shadow can only be cast on a body where it would otherwise be in light; the value or intensity of the cast shadow is in direct proportion to the intensity of the light at the same point.

Such is the theory explained for a very simple geometrical solid; examine its application to a fragment of architecture, for example, the capital of a Doric column and its architrave

Naturally, cast shadows have less reflections. Indeed the bending of light producing reflections comes from lighted bodies varying greatly in nature, but which in theory can only be regarded as secondary sources of luminous rays, whose resultant will be parallel to the light rays, but with the inverse direction. In certain respects it may be said, that the phenomena of reflections and of elasticity are identical. Thus while the light has a direction of 45° downward from left to right (conventionally), the direction of the reflections will be upward and from right to left.

This theoretical convention is too absolute but is necessary, and will be the rule for your shading. Commence with the lights, where the tints are more easily understood.

Assume a solid in white stone, for example a sphere (Fig. 17). It is easily seen that the brightest lighting acts at the point of intersection of the surface by the luminous ray passing through the centre; outside this pole of light, the angles of the luminous rays with the surface constantly diminish in parallel zones with the luminous point astheir pole, until they become tangent to the sphere in a great circle, having the luminous point as pole, and which is the line separating the shadow and the light. The light then diminishes from the pole to the equator.

The reverse sense is true in the shadow, for the maximum reflection will be at the other end of the diameter passing through the luminous point, and the shadow diminishes in inten sity from the circle separating the shadow and light to that pole of reflections.

But if any body casts a shadow on the lighted portion of the sphere, that cast shadow will have less strong reflections and is therefore more intense than the shadow of the sphere, and the more intense, since it falls on a more strongly lighted part of the sphere.

Therefore two rules for shading; a shadow can only be cast on a body where it would otherwise be in light; the value or intensity of the cast shadow is in direct proportion to the intensity of the light at the same point.

Such is the theory explained for a very simple geometrical body. Examine its application to a fragment of architecture, for example, the capital of a Doric column and its architrave,

(Fig. 18). The shadows are traced and a first shadow tint is passed. What will be the most intense shadow? Evidently the cast shadow A determined by a ray normal to the cylindrical surface of the column and the parts A' A' of the cast shadows that meet the surface of revolution along its meridian of light. The lightest reflections are not visible in the drawing, but occur behind the projection and on the meridian opposite the point A. But for the parts visible, those most affected by reflections will be the points B, B, doubly reflected by their position in plan and by the form of the moulding. Between these extremes the middle parts C, C will have intermediate values, either as actual shadows or as cast shadows, observing that the outline C' with relation to the light, is symmetrical with the parts C, C. There will then be symmetry of shading with reference to an axis of lighting for the luminous parts and of the intensity of shadows, which will be the meridian A.

As for the straight mouldings D, D, their general value will be analagous to that of the middle values C, C.

Passing to the lights, we see that the point most lighted will be the point a, and then the generatrix a', a', and that light will become more and more darkened toward the tangent m, m. But along the astragal the light increases, for it strikes the cylinder more normally.

As for the plane parts, abacus, architrave and fillets, they receive less light than the cylinder at a',a',and sensibly as at C, C, but the slope will be more lighted, moreover, each of these plane surfaces in shadow or light will be made lighter from top to bottom on account of reflection due to the ground, and the distances will be indicated as I have done before.

For the detail of each part the same reasoning is applied. Thus for the core, a shadow is cast downward, and at the same time an actual shadow above the tangent T. The shadow is shaded by continuous lighting from top to bottom. For the ogee, there are cast shadows O and P, an actual shadow at N with reflections.

From the preceding will result a general shading as in the example of (Fig. 19).

But another element frequently affects the shading, recesses

or projections. A recess is always darker than a simple shadow, for scarcely any reflection appears there to lessen the shadow. Such are openings in a facade, as in the example taken from the Procuratio of Venice (Fig. 20). Likewise projections less accessible to reflections will be darker than the adjacent shadows. So the spaces between dentils, between consoles or modillions, etc., produce the effect of a recess in the general shadow.

Yet the shading should be such that the parts appear in the drawing as in reality; there should be no exaggerations and the shading should remain simple. For this are necessary skill, a formal taste, and good models at commencing.

Lacking direct models, photographs of good wash drawings are easily procured; thus a great number of drawings sent from Rome have been photographed or published; those are models that cannot mislead.

I should also state plainly that I do not pretend to train draftsmen by some rules. Yet it is excellent to be guided by a method, especially in beginning. If this seems to you rather arduous and complex, you will conclude that architectural drawing is not so elementary as supposed, and that on the contrary it demands much reflection and study, without mentioning the artistic and personal qualities that you bring with your nature and impressions, but only after many efforts. Remember always that a drawing is made with precision and accuracy, and that the rendering is done by shading.

## Chapter 5. Copied Drawings.

Summary. --Drawing in general. --Form and proportions. --Setting. --Choice of models. -- Conclusions from the preceding.

The term copied drawings is accepted and understood, but does not please me, lowering drawing to a mechanical function, whose ideal would be photography or still life. Now it is essential for the ambitious draftsman to have a higher idea of drawing.

Drawing is first of all a profound and intimate perception of the entire spirit of the model by the intelligence of the draftsman. It is the difficult art of seeing. Every drawing is a conquest and a taking into possession.

This drawing is a work primarily of intelligence. An unintelligent person will never be a draftsman. Nor a light and superficial mind; the study of drawing is noble and severe; and you must first be convinced of this.

Observe at the Louvre Giocondo and Leonardo da Vinci among other masterpieces of drawing. How could that great artist and great man make the portrait, that for four centuries has impressed itself on the admiration as the absolute type of drawing in the noblest sense of the word? Is it a happy improvisation, a success of skill in procedure, of some quality or of good fortune, always secondary, sometimes echoed by the artisan in drawing, the tricks of the painter? Nowise, and these tricks of petty ambition were despised too much by Leonardo to possess them. On the contrary, do you not see the whole soul of the great artist put into his work, all his intelligence aroused to thoroughly know such a complex model, and finally the full possession of that model, whose entire soul without any secret reticence becomes the artistic treasure of the painter, whose work is truly a creation, for what you see is not only the Giocondo, but what Giocondo saw, such as expressed by the profound study and sovereign genius of Leonardo da Vinci.

If I show you these heights, this is not to propose them as your aim, but it is to indicate to you at least as an ideal of what drawing should be. And first I desire to show you the frequently unknown fact, that the study of drawing is first of all a work of intelligence. But also much practice and ex-

ercise is required, system and instruction. You really learn to draw in a course in drawing; if all courses in drawing were good, my advice would be limited.

Unfortunately the laudable efforts made for some twenty years to create systenatic and rational instruction in drawing have not been free from ancient errors and false ideas, or rather tha absence of ideas and of methods. In this respect you will be favored more or less; in any case it is well for you to receive some rules to guide you in your studies.

Drawing is first of all the expression of form and of proportion. Do not hasten to seek effect, to rush into shading, before being certain of your preparation, which is the important matter.

For this preparation the primary ideas of perspective are indispensable. Certainly if your eye by a very rare physical gift is as accurate as an instrument of precision, you will be saved from faults, but even in that favorable case, two guarantees are better than one, and perspective permits you to control what you see, i. e., what you think you see.

Never forget that learning to draw is learning to see. Nothing surprises a layman so much as when told that he cannot see; yet nothing is more true; we only learn to see after long training of the mind and of the eye. I give a single proo you see on the right and left two objects distant from each other, for example a man and a horse; abruptly ask yourself which appears the larger; it rarely happens that you are not mistaken. Make the experiment.

Therefore learn to see, for this is drawing. When the eye sees, the work of the hand is nothing. Take some days of apprenticeship to acquire this dexterity of the hand, when years will not suffice for learning to see.

Never waste time on the system, that spends long months in copying engravings. That teaches nothing. If you do copy, let it be photographs of drawings of the masters and not the odious drawing models, that have made so many victims. But draw from the well lighted plaster cast, and if possible commence by drawing at night by lamplight. Take easy models at first, finally models with their own forms and relief. Drawing is translating, but never translate translations. Too frequently the pupil is made to draw something of no importance on the pretext that it is always an exercise. Doubtless it may be a difficult to draw accurately some frightful bust escaped from a shooting gallery as those admirable antique busts of Homer, Demosthenes or Cato. But what becomes of the education of taste, if the pupil is daily in contact with what can only reprove it? Your models must be beautiful, and in the antique will they be found.

Choose in preference very clear models, where the forms are [illegible] distinct and not worn or rounded by time or by the author. They should also be clean, for otherwise the dirt will be confounded with the relief, and you will frequently err in the form to be rendered, for the dust falls on the parts of the model, that should be best lighted by ordinary light, for example on the top of the head.

But I speak of the bust, i.e., drawing the head, which may surprise you, for in your career you will have to draw ornament rather than the head. Only by drawing the head of the [illegible] the bust of Homer, it will be only play to design a scroll or console; always because to learn to draw is learning to see; [illegible] proportion and observation are everything. You can never be too good draftsman.

Must I add that your drawing must always be serious? Leave the givers of recipes, professors of hatching and of tricks. [illegible] ly observe the peculiarity of the model and its character. [illegible] yet skilful in drawing it. After commencing your drawing, change neither plane nor direction, nor give a stroke of [illegible] draw a head well when you see its face, after seeing and understanding its profile.

[illegible] ing, which is drawing expressed with moist clay instead [illegible] A little practice quickly suffices to acquire manual skill.

pretext that it is always an exercise. Doubtless it may be as difficult to draw accurately some frightful bust escaped from a shooting gallery as those admirable antique busts of Homer, Demosthenes or Cato. But what becomes of the education of taste, if the pupil is daily in contact with what can only deprave it? Your models must be beautiful, and in the antique will they be found.

Choose by preference very clear models, where the forms are distinct and not worn or rounded by time or by the author. They should also be clean, for otherwise the dirt will be confounded with the relief, and you will frequently err in the form to be rendered, for the dust falls on the parts of the model, that should be best lighted by ordinary light, for example on the top of the head.

But I speak of the bust, i.e., drawing the head, which may surprise you, for in your career you will have to draw ornament rather than the head. Only by drawing the head of the human body can one learn to draw. If you succeed in drawong well the bust of Homer, it will be only play to design a scroll or console; always because to learn to draw is learning to see; nothing teaches to see better than drawing the head with its infinite variety and delicate shades. In drawing accuracy, proportion and observation are everything. You can never be too good draftsmen.

Must I add that your drawing must always be serious? Leave the givers of recipes, professors of hatching and of tricks. Procedure is nothing, but identity of the drawing and the model is everything. Then commence by thoroughly knowing your model; never be in haste to take up the pencil; first carefully observe the peculiarity of the model and its character. If you do not find something to be understood in it, you are not yet skilful in drawing it. After commencing your drawing, change neither plane nor direction, nor give a stroke of the pencil without first glancing at the model; you will only draw a head well when you see its face, after seeing and understanding its profile.

Now review this advice, changing the word drawing to modeling, which is drawing expressed with moist clay instead of charcoal or pencil, and the only difficulty is to learn to see A little practice quickly suffices to acquire manual skill.

But here again instruction is necessary. I can only give general advice, desiring for you a serious instructor, to direct you slowly and surely in the path of true drawing and modeling, before models chosen to form your taste.

## CONCLUSION.

This is the programme of your preparatory studies, made anywhere without the need of a School of Fine Arts or of Architecture. The general instruction required for all liberal careers may be acquired anywhere, and the modest scientific instruction mentioned. Drawing is taught everywhere today, even if it is not always what it should be, yet choice is possible and the young man can always find a useful and serious master.

After stating what should be studied, I find it necessary to advise you not to study architecture now!

We consider here the preparatory studies very important, for if lacking, this injures your entire life. Then finish them.

No impatience nor presumption. For good officers is required serious preparation in literature, history and science; candidates do not have to prove having played soldier in school battalions. Architecture for you will come later, when you are prepared, and after preparing for architecture, you will have preparation in architecture before attaining to composition. Order and system are economy in studies.

Only at this point, examine yourselves conscientiously. If this preparation in all its elements permeates you, if you have a taste for it, and feel that you are indeed the man for these studies, proceed; otherwise stop here.

This advice is far from being complete; there is yet much to say before the final advice, that will crown your studies:- the schools teach only what they can--very little in comparison to what you owe yourselves by reflection, by virile and continued effort, by the spirit of your requirements from yourselves, by respect for your art and your conscience. If instruction gave all knowledge and all talent, all industrious pupils would be equal. Far from that:--but realize well, that if there are actually natural gifts that are good fortune, also and above all are acquired gifts, that are a recompense, and each one of you, as an artist, will merit what we will be. Never forget this.

I have thought it useless to touch upon lengthy and always elevated studies without an initiation into the labors and joys always reserved by these studies, desiring you to enter at the same time the promised land, which must be merited. We now commence the architectural studies.

# BOOK II. GENERAL PRINCIPLES.

SUMMARY. --General statement. -- Inaugural lecture of the Course on Theory of Architecture. --Permanent principles. -- Great rules of composition. -- General proportions. -- Specific proportions. -- Proportions of halls. --Corollaries of the study of proportions. -- Art and Science of construction.

## Chapter 1. Programme of Theory of Architecture.

SUMMARY. --General statement. -- Inaugural lecture of the Course on Theory of Architecture at the School of Fine Arts. -- General programme.

I commence here the editing of the Course of Theory of Architecture, that I have given since 1894 at the School of Fine Arts.

Whenever necessary there will be added more elementary suggestions for the useof beginners. The order of the course will be followed, first reproducing the inaugural lecture as taken down by stenography.

This lecture is only the programme of the studies of the architect; the principles stated were confirmed by the approv al of all the masters of instruction present, so that this advice may be regarded as given by those experienced in our studies; and although containing certain explanations peculiar to the School of Fine Arts, I give it in full.

# INAUGURAL LECTURE OF THE COURSE ON THEORY OF ARCHITECTURE AT THE SCHOOL OF FINE ARTS NOVEMBER 28, 1894.

Gentlemen:-- In taking possession of this chair of Theory of Architecture, my first duty is in the name of my colleagues, yourselves and myself, to address a heartfelt farewell and a memorial of cordial sympathy to my predecessor and friend, Edmond Guillaume.

You have studied under his direction, have learned to appreciate in him the assured artist, the man of duty, of high intelligence and experience. Of all qualities necessary to the architect, Guillaume possessed above all that quality of sagacity, precious everywhere and especially in teaching. He was a man brought up in sane traditions, with a passion for study, love of duty, and thus he brought into his functions of professor an absolute devotion; yet this devotion was easy for him, because he loved his studies, his pupils and his art.

Gentlemen, I believe and am certain, that you will preserve a faithful memory of him, a remembrance such as should always remain in the hearts of artists for men, who have initiated you into artistic enjoyments, who have aided in your instruction, who have sought to make you the artists of the future.

These regrets expressed for the premature loss of M. Guillaume, I should accompany by a personal regret, that of succeeding him.

It is my custom to say plainly what I think, and I owe it to you to state simply why I am here.

After the death of M. Guillaume, pressing, friendly and very honorable suggestions were made to me; friends and colleagues desired to insist that I should ask to succeed him. But I had other instruction, students, an atelier, and from beginning to end declined to make that request. I said that "I would not present myself," and indeed, gentlemen, I have not offered myself for the place; But the Superior Council of the School has a right to present a candidate for the office, not indeed without consulting him, but almost compelling him, if necessary. Closely questioned on this matter, I finally replied, that if the Superior Council clearly indicated to me a duty to fulfil in the interest of the School, an act of devotion to perform, and a sacrifice to be accepted, I would neither avoid the duty nor the responsibility . That is what occurred. The Superior Council was unanimous in designating me for this post, even more perilous than the one previously occupied. I was greatly honored and was certainly touched. I obeyed and now appear before you.

My young hearers, I certainly do not need to say to you, that only with profound regret do I abandon instruction in the atelier for more than twenty-five years. You know best of all what this teaching is. Atelier instruction is the required artistic instruction; all courses of lectures might disappear, but the School of Fine Arts would still remain, while one cannot conceive the School without the ateliers. That instruction is venerable artistic teaching, and you have on that wall of the Hemicycle in the School of Fine Arts (predecessors and guarantors. In the atelier the professor is abso-lute master of his theory, of his esthetics, of lectures giv [illegible] even of his boldness and his utopias, for in case of error on his part or even of incompatibility, there is a necessary cor-rective; if his teaching does not please, is unsuited to the [illegible] you have choice of masters. The word "professor" does not properly designate the head of the atelier. Our [illegible] entirely special character and originality. While other schools and even the greatest in France may claim for their [illegible] hesitates with them, without false modesty, showing [illegible] tures and turn of mind; that one needs encouragement [illegible] its progress, then "that is very bad" before a study such [illegible] considering the personality of its author. He pri [illegible] nor substitutes, but makes valuable the natural gi [illegible] sources offered by each personality, happy if he h curred. The Superior Council was unanimous in designating me for this post, even more perilous than the one previously occupied, I was greatly honored and was certainly touched. I obeyed and now appear before you.

My young hearers, I certainly do not need to say to you, that only with profound regret do I abandon instruction in the atelier for more than twenty-five years. You know best of all what this teaching is. Atelier instruction is the required artistic instruction; all courses of lectures might disappear, but the School of Fine Arts would still remain, while one cannot conceive the School without the ateliers. That instruction is venerable artistic teaching, and you have on that wall(of the Hemicycle in the School of Fine Arts)predecessors and guarantors. In the atelier the professor is absolute master of his theory, of his esthetics, of lectures given, even of his boldness and his utopias, for in case of error on his part or even of incompatibility, there is a necessary corrective; if his teaching does not please, is unsuited to the nature of some students, the ateliers outside are open, and you have choice of masters. The word "professor" does not properly designate the head of the atelier. Our School has an entirely special character and originality. While other schools and even the greatest in France may claim for their benefit superior instruction, transcendent instruction, seek names for this instruction of which you have an exalted idea; our own School of Fine Arts has its own teaching, friendly instruction. Here the master is an experienced friend to guide his young friends, advising them, studies, experiments and hesitates with them, without false modesty, showing how to seek, to find, and even why one fails to find. He is an older friend of his pupils, must know their temperaments, natures and turn of mind; that one needs encouragement, another severity; who should be pushed and who restrained; he will say "That is very good"before a mediocre study, that exhibits progress, then "That is very bad" before a study much better than the former, but which shows a temporary decadence, considering the personality of its author. He primarily bases his advice on the nature of the student, he neither deforms nor substitutes, but makes valuable the natural gifts and resources offered by each personality, happy if he has formed

very different students, that are neither copyists of their comrades nor of their master.

For this instruction is required especially one quality, one temperament, one virtue, that the master must be a man of feeling. Without this can be no artistic teaching. Talent does not suffice, but enthusiasm must lavish itself, ardent and warm expansion; there is necessary the friendship already mentioned, causing the student to have entire confidence in his master, that he knows he can count upon his students, that he will be rewarded for his efforts by those around and beside him.

The reverse of the medal is well known to me, the weaknesses, sorrowful mistakes, continual beginnings; if this high mission is often a labor of Sisyphus, no matter, for Sisyphus is sustained by the faith that transfers mountains, and always permits the ascension of the highest peaks.

Gentlemen, is not this description faithful, in which you have certainly recognized your masters, whose lectures you loved?

That instruction I left with profound regret, and I am convinced that you know this is not mere rhetoric.

On leaving it I brought a memory precious through my entire life and for my family, of having fulfilled my task with loyalty and devotion.

Gentlemen, I am now before the course in Theory of Architecture and am first obliged to ask, what should be this course? The question may seem strange, for the course has existed for many years, and has been given here by men of great worth. Its tradition should be established, and yet-- I speak plainly now as always-- I feel around me an impression, that this course is to be created.

Its difficulty is, that this course in Theory of Architecture is in danger of becoming a restraint, a contradiction to the instruction, that your masters have a right to give you.

The originality of our School is, that it is the most liberal in the world. This quality is denied to it by some Frenchmen, doubtless for having neglected their right to instructio strangers that attend it or remember sitting on its benches p claim this, and recently an American, a good judge of freedom, who came to Europe expressly to study art schools and select in all Europe the ideas most favorable for his country, said to me:--"What distinguishes your School from those seen in Italy, Germany, England and Austria"--he had just traveled throughout Europe--"is its absolute freedom, the treating of the student as a man with the right to choose his master and his artistic course!"

But Gentlemen, permit a personal remembrance of some com- [illegible] an event, that might have been comic, had it not been danger- [illegible] of that, but it was desired to create compulsory examinations in esthetics. That excited us, and some comrades and myself otained somewhat by surprise an audience of the minister of Fine Arts. He was an old soldier, very firm for obedience, al [illegible] much astonished that his wishes could be discussed, if his wishes were his own and not suggested by others. A marshal of France, for that was his rank, intimidated me far less th [illegible] say:-- "Esthetics is the religion of the artist. To institute with us a state doctrine, state esthetics, compulsory esthetics, would take us back to a time unknown to us young [illegible] appointment--or a commission-- it was necessary to confess by showing a certificate of confession."

I should state that this observation was received as [illegible] this anecdote, it is to show you, that already while a student here, I had a feeling for liberty of instruction, [illegible] student, it is not to impose on you today as professor [illegible] state doctrine or faith, to attack your liberties, and [illegible] dom of your masters.

[illegible] and excellence of a doctrine, of the service rendered by [illegible] truth, it might easily become too doctrinal and too [illegible] Not in our absolutely liberal School, for if necessary [illegible] in all Europe the ideas most favorable for his country, said to me:--"What distinguishes your School from those seen in Italy, Germany, England and Austria"--he had just traveled throughout Europe--"is its absolute freedom, the treating of the student as a man with the right to choose his master and his artistic course!"

But Gentlemen, permit a personal remembrance of some comrades and myself. At a time when our School passed through an event, that might have been comic, had it not been dangerous, a course in esthetics was created. I have nothing to say of that, but it was desired to create compulsory examinations in esthetics. That excited us, and some comrades and myself obtained somewhat by surprise an audience of the minister of Fine Arts. He was an old soldier, very firm for obedience, and much astonished that his wishes could be discussed, if his wishes were his own and not suggested by others. A marshal of France, for that was his rank, intimidated me far less than an artist of worth, and in that audience I allowed myself to say:-- " Esthetics is the religion of the artist. To institute with us a state doctrine, state esthetics, compulsory esthetics, would take us back to a time unknown to us young people, but which our elders might recall, when to obtain an appointment--or a commission-- it was necessary to commence by showing a certificate of confession."

I should state that this observation was received as badly as possible, yet finally the examinations in esthetics did not occur. I do not desire the merit at all, but if I relate this anecdote, it is to show you, that already while a student here, I had a feeling for liberty of instruction, a fear of a state religion or doctrine; and if I had that fear as a student, it is not to impose on you today as professor a state doctrine or faith, to attack your liberties, and still less, for it would be even more singular, to attack the freedom of your masters.

This indeed is the danger of the course in Theory; in the hands of an artist too strongly convinced of the superiority and excellence of a doctrine, of the service rendered by him in teaching authoritatively what appears to him as thesole truth, it might easily become too doctrinal and too personal. Not in our absolutely liberal School, for if necessary for me speak of a theory of architecture, it is not necessary for me to speak of my theory of architecture; the difference is sensible and will not be forgotten.

What then will be my domain?

What is incontestable, for all that is or may be contested is the domain of my colleagues; what is not contested, essentially the why and the how, is what I may undertake, and of which I may speak to you, which subject is still quite vast.

As for instruction, my profession of faith is very clear. I am firmly convinced that in all things, particularly in architecture, the artistic studies should be essentially classical. To be classical is not to bind one's self to a party, to be exclusive or to proscribe, neither is it to close the eyes nor to restrict the course taken, but to place as the basis of [illegible] the elements consecrated by experience, classical tradition, a firm respect for superior principles. The classic is in stable equilibrium.

Certainly fancy and caprice are sometimes charming when justified by talent — insupportable when exhibiting merely pretense without talent. [illegible] escape in reasoning, and in caprice even must be a basis of logic only acquired by classical studies. There is indeed a [illegible] license, yet this must be [illegible], and to free one's self momentarily from a principle, this must be known.

But this fine title of classical as a definite canonization in art is not an affair of origins or of dates, of centuries or of latitudes. Classical is all that merits remaining so, without respect to time, country or school. The classical does not impose itself; one can only verify and register it. The classical is all that remains victorious in the eternal struggles of the arts, all that remains in the [illegible] of the admiration universally proclaimed. And all its patrimony confirms the same invariable principle, reason, logic and method, through an infinite variety of combinations or of forms.

The classical is not the privilege of any time, country or school. The classical is Dante as well as Virgil; Shakespeare as Sophocles; [illegible] [illegible] as much as [illegible], Palladio or [illegible], and for all it is the Parthenon, the [illegible] or the [illegible], etc.

speak of a theory of architecture, it is not necessary for me to speak of my theory of architecture; the difference is sensible and will not be forgotten.

What then will be my domain?

What is incontestable, for all that is or may be contested is the domain of my colleagues; what is not contested, especially the why and the how, is what I may undertake, and of which I may speak to you, which subject is still quite vast.

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I am firmly convinced that in all things, particularly in architecture, the primary studies should be essentially classical. To be classical is not to bind one's self to a party, to be exclusive or to proscribe, neither is it to close the eyes nor to restrict the course taken, but to place as the basis of the studies the elements consecrated by reason, logical traditions, a firm respect for superior principles. The classic is in stable equilibrium.

Certainly fancy and caprice are sometimes charming when justified by talent-- insupportable when exhibiting merely pretense without talent. These matters are too personal to not escape in teaching, and in caprice even must be a basis of logic only acquired by classical studies. There is indeed a happy license, yet this must be conscientious, and to free one's self momentarily from a principle, this must be known.

But this fine title of classical as a definite canonization in art is not an affair of origins or of dates, of centuries or of latitudes. Classical is all that merits becoming so, without respect to time, country or school. The classical does not decree but imposes itself; one can only verify and register it. The classical is all that remains victorious in the eternal struggles of the arts, all that remains in possession of the admiration universally proclaimed. And all its patrimony confirms the same invariable principle, reason, logic and system, through an infinite variety of combinations or of forms.

The classical is not the privilege of any time, country or school. The classical is Dante as well as Virgil; Shakespeare as Sophocles; the Soir of the Vallon, Rolla or the Nuit d' Octobre as much as the Cid, Polyeucte or Athalie, and for us it is the Parthenon, the Baths or the Amphitheatres, St.

[illegible] St. Peter, Palace Farnese or the Louvre. And such has always been the broad and philosophical conception of our School, since in that painting, [illegible] the Pantheon of Art, are grouped [illegible] masters of the most varied schools, all these grand classics of inspired ages!

Yet one cannot describe architecture without showing its historical evolutions; I shall have to do so on occasion, but with this important reserve; history is an explanation, but a misfortune to professor or student, who restricts the study of architecture within the limits of a historical study! To study this history usefully, must first be known its materials and the elements of architecture. [illegible] for these without that necessary preparation, the history of an art is no more than that of archaeology. Thus isolated, archaeology, that should be the auxiliary of the arts, may be their most formidable enemy. [illegible] for the arts.

For a century, and in the entire world, arts and architecture have been in a condition of anemia by their subordination to archaeology. Had we a Raphael or a Paul Veronese, they would not be allowed to produce either the School of Athens or the Marriage at Cana, [illegible] admirable masterpieces that they are incorrect! Architecture is today required to be contemporaneous with St. Louis, France with Louis XV, and is abroad now merely an archaeological expression, a servile adaptation of illogical anachronism, like the epoch furnishing the model for imitation. [illegible] are conceived utilitarian Parthenons; at London, to correspond [illegible] will find old acquaintances, Palace Farnese, the Procuraties, or the Colonnade of Place de la Concorde, everything copied even to the reliefs for greater servility. Italian art only [illegible] a youthful country, but as aged in art as old Europe.

France alone has protected itself, and thus there is still

Sophia or Notre Dame, St. Ouen or St. Peter, Palace Farnese or the Louvre. And such has always been the broad and philosophical conception of our School, since in that painting, which is the Pantheon of Art, are grouped to preside over your studies the incontestable masters of the most varied schools, all these grand classics of inspired ages!

Yet one cannot describe architecture without showing its historical evolutions; I shall have to do so on occasion, but with this important reserve; history is an explanation, but a misfortune to professor or student, who restricts the study of architecture within the limits of a historical study! To study this history usefully, must first be known the materials and the elements of architecture. History then confirms the sane studies, exhibits climaxes coinciding with the accepted discipline of principles, decadences fatally expiating their neglect, renaissances illuminating their awakening. But for these without that necessary preparation, the history of an art is no more than that of archaeology. Thus isolated, archaeology, that should be the auxiliary of the arts, may be their most formidable enemy. The question is grave and indeed merits a cry of alarm, for it is a question of life and death for the arts.

For a century and in the entire world, arts and architecture have been in a condition of anemia by their subordination to archaeology. Had we a Raphael or a Paul Veronese, they would not be allowed to produce either the School of Athens or the Wedding at Cana, for archaeology objects to these admirable masterpieces that they are incorrect! Architecture is today required to be contemporaneous with St. Louis, tomorrow with Louis XV, and is abroad now merely an archaeological expression, a servile adaptation of illogical anachronisms, like the epoch furnishing the model for imitation. At Munich are conceived utilitarian Parthenons; at London, to correspond to the entirely modern requirements of the Club, you will find old acquaintances, Palace Farnese, the Procuratios, or the Colonnade of Place de la Concorde, everything copied even to the reliefs for greater servility. Italian art only knows how to repeat; everywhere the same, and even in America, a youthful country, but as aged in art as old Europe.

France alone has protected itself, and thus there is still

a French school! Yet we have almost fallen asleep under the air pump. At the beginning of the century, the only esthetics was to first conceive a Roman edifice--at least in intention; then this bed of Procrustes tortured modern life and requirements. A little later was first substituted the medieval architecture of a civilization yet more different from ours. Between these two purely archaeological camps was a bitter war; Eteocles and Polynices did not see that they were brothers in the same servile condition and the same faith of anachronism.

Happily, bold artists-- our masters-- have seen and proved that independence does not consist in changing livery, and our art has gradually freed itself from that paleontology. All has not been uniformly happy, but all efforts toward that end have been fruitful, and today we know and proclaim that art has a right to freedom, that liberty alone can ensure life, fertility, even safety!

If I emphasize these considerations, it certainly is not to destroy everything preceding us; on the contrary, our art like our language and our civilization are a heritage, a rich patrimony gathered during centuries. But I hate artistic proscriptions like all others, artistic exclusivisms, and I seek to exhibit in what both broad and severe a sense I understand the word classical, that I claim for the motto of our studies.

One restriction only, and that a conventional one.

Among the works of your masters, happily for an epoch, some will not only become classical in futute, but are already so today. You should understand that instructors cannot and should not select examples among the works of living artists, because the professor does not wish to be accused of offering incense. Therefore in my examples I shall restrict myself to that too natural limit, whatever loss may result for my theories and your instruction; I shall select only among the works of those already made our predecessors by death, excepting for certain subjects with substantially contemporaneous solutions, such as the school, the hospital, etc. It is there necessary to borrow from the living.

Gentlemen, this is the spirit of the Course in Theory.

Then what will be the divisions?

These divisions appear to be indicated by the nature of things. In the School of Fine Arts are students at all stages of instruction, beginners just admitted yesterday, those of the intermediate stage, and the veterans leaving the [illegible] together, all degrees of advancement in similar extent, and this course must be addressed to all, with nothing too arduous for beginners; as for the veterans, they can hear everything with benefit, which will be especially addressed to [illegible] as well as the first principles, that they will be interested in recalling. In art subjects are not to be classed, classed elementary; what alone elevates subjects is the elevated fashion of treating them; the elevation of the subject is at the height of the intelligence of the artist.

I believe that the division should be this:—after having established as concisely as possible the general and invariable principles of the art,—principles identical in all the great artistic epochs in spite of the profound differences in external forms,—the architect must first become acquainted with the elements at his disposal, the arsenal of architecture, to compose with walls, doorways, windows, piers, columns, vaults, ceilings and stairways; all these are elements, which I call the elements of architecture. This appears to me as logically the first part of a course, and I believe that on these matters only apparently modest, interesting things are to be said; not that I may say them, but that are to be said. The matter is very elevated, I repeat emphatically; nothing in art may not be high instruction; nothing in the study may not be elevated. When the most skilful among you obtain the grand prize and go to pass four years in Italy and Greece, what is first done in accordance with the rules of the Academy, wise rules made by men with a profound acquaintance with the needs of artistic instruction? You commence by studying the elements more profoundly and in detail, and in a deeper fashion, the same elements previously studied at the beginning of your studies; sometimes the pensionary at Rome merely makes again at great length a careful drawing of something, that perhaps was even the subject of his [illegible] admission to the School.

After these elements of architecture, I see what I shall term the elements of composition. Composition is the [illegible]

These divisions appear to be indicated by the nature of things. In the School of Fine Arts are students at all stages of instruction, beginners just admitted yesterday, those of the intermediate stage, and the veterans leaving the School tomorrow. All degrees of advancement in studies exist, and this course must be addressed to all, with nothing too arduous for beginners; as for the veterans, they can hear everything with benefit, which will be especially addressed to them, as well as the first principles, that they will be interested in recalling. No art subjects are to be disdained, however elementary; what makes elevated subjects is the elevated fashion of treating them; the elevation of the subject is in the height of the intelligence of the artist.

I believe that the division should be this:--after having established as concisely as possible the general and invariable principles of the art,--principles identical in all the great artistic epochs in spite of the profound differences in external forms,--the architect must first become acquainted with the elements at his disposal, the arsenal of architecture. He composes with walls, doorways, windows, piers, columns, vaults, ceilings and stairways; all these are elements, which I term the elements of architecture. This appears to me as logically the first part of a course, and I believe that on these matters only apparently modest, interesting things are to be said; not that I may say them, but they are to be said. The matter is very elevated, I repeat emphatically; nothing in art may not be high instruction; nothing in the study may not be elevated. When the most skilful among you obtain the grand prize and go to pass four years in Italy and Greece, what is first done in accordance with the rules of the Academy, wise rules made by men with a profound acquaintance with the needs of artistic instruction? You commence by studying the elements more profoundly and intimately and in a deeper fashion, the same elements previously studied at the beginning of your studies; sometimes the pensionary at Rome merely makes again at great length a careful drawing of something, that perhaps was even the subject of his co petitive admission to the School.

After these elements of architecture, I see what I shall term the elements of composition. Composition is the combinstion in an entirety of all the different parts, whose re- [illegible] to com- pose, i.e., to make from them an entirety.

[illegible] the different halls, what may be the different porticos, vesti- bules etc., what are bays of a facade, pavilions, interiors and exteriors, not from the point of view of beautiful examples, which you must know in the domain of art. When you compose, it is necessary to be rich enough in knowledge to be able to recall [illegible] most beautiful models; you must be able to say to yourselves, "Here is a hall that I should like in [illegible] of the Palace Royal in Paris; this pavilion should have the amplitude of those of our Place de la Concorde, or the ele- gance of those of the Cancellaria at Rome." I could indefini- tely multiply these examples, and they suffice to show what are the elements of composition.

Finally, there is a third part, but I do not promise to [illegible] you today in a tentative state, that at present I do not know [illegible] prepare.

However, this third part — nothing less than all composi- tion— would be the comparison of edifices or comparative ar- chitecture. Taking the programme of a theatre, for example, if I could tell you what the theatre was in antiquity, at dif- ferent epochs approaching our own time, and what it is today in France, in Europe and America, if I could collect and place before you the complete statement of this question of the theatre, I could not finish it and say to you:—"This is how you should make a theatre." This is not my part, for it would be my own theory. I would say to you:—"Such is the state of the matter, and this is the state of advancement of [illegible] in your turn and perhaps you may excel your predecessors."

[illegible]

ation in an entirety of all the different parts, whose resources and means should be known before pretending to compose, i.e., to make from them an entirety.

You will compose usefully only on condition of knowing the different halls, what may be the different porticos, vestibules etc., what are bays of a facade, pavilions, interiors and exteriors, not from the point of view of beautiful examples, which you must know in the domain of art. When you compose, it is necessary to be rich enough in knowledge to be able to recall the analogy of most beautiful models; you must be able to say to yourselves, "Here is a hall that I should love to design in the character of the halls of Versailles, or of the halls of the Palace of Justice or of the Louvre; this stairway should be analogous to that of the Palace of Caserta or of the Palace Royal in Paris; this pavilion should have the amplitude of those of our Place de la Concorde, or the elegance of those of the Cancellaria at Rome." I could indefinitely multiply these examples, but they suffice to show what are the elements of composition.

Finally, there is a third part, but I do not promise to touch on it; it would be so vast and perhaps is reserved to your masters in the ateliers, and that its place is not in the course on Theory. I must further confess that I am before you today in a tentative state, that at present I do not know just the limits and the extent of this course, which I must prepare.

However, this third part-- nothing less than all composition-- would be the comparison of edifices or comparative architecture. Taking the programme of a theatre, for example, if I could tell you what the theatre was in antiquity, at different epochs approaching our own time, and what it is today in France, in Europe and America, if I could collect and place before you the complete statement of this question of the theatre, I could not finish it and say to you:--"This is how you should make a theatre." This is not my part, for it would be my own theory. I would say to you:-"Such is the state of the matter, and this is the state of advancement of this research, that has lasted so long and is not yet finished. Seek in your turn and perhaps you may excel your predecessors."

But for such a vast scheme would the entire life of a man [illegible] analyzed and condensed everything? I cannot engage to do this only assured of my good intentions, but not of a power of encyclopedic concentration, perhaps not in the power of any one.

Furthermore, a great difficulty that I consider, and one [illegible] material that is of a nature to cause reflection and qualities in a certain measure, is the absence of drawings. [illegible] by a sketchy summary, while the architectural courses in the schools, where there are [illegible], have at hand numerous drawings, our course in theory has no collection. I do not know what I am to do, and can [illegible] in that respect; but I am obliged to state to you, that instruction in the theory, as I [illegible] it, will be extremely difficult, unless I can [illegible] my drawings at large scale, [illegible] speaking, what I am to say to you, for you cannot have absolutely all the edifices in memory, of which I shall have to speak.

For all this [illegible] what I can [illegible] will be the programme of my course. Further, I do not desire to restrict myself to a series of manuscripts prepared in advance. I have to study and try everything, to seek with you; I request a [illegible] credit, [illegible] will that you cannot doubt.

The course in Theory, or rather the functions of the professor of Theory, comprises another important question, that of the programmes, of such importance, that I voluntarily say, and this I believe to be your own opinion, that essentially [illegible] of the programmes and the professor of Theory have a durable and permanent effect on your studies. Because of this capital question I have desired to present before you this inaugural lecture, before you have received the first programmes signed by me, because I have something to say on that subject, and you may perhaps feel some surprise next [illegible] programmes, that may differ to a certain extent from those you are accustomed to receive.

To make a good programme is difficult, and very difficult to make a good series of programmes. There is required a system, a sequence of ideas; a constant attention to the [illegible] [illegible] that [illegible]. Yet with all these reserves, I will state my mode of thought.

suffice? Would it then be necessary to know, to have studied, analyzed and condensed everything? I cannot engage to do this, only assured of my good intentions, but not of a power of encyclopedic concentration, perhaps not in the power of any one.

Furthermore, a great difficulty that I consider, and one although material that is of a nature to cause reflection and hesitation in a certain measure, is the absence of drawings. By a singular anomaly, while the architectural courses in the schools, where these are but accessary, have at hand numerous drawings, our course in theory has no collection. I do not know what I am to do, and can secure in that respect; but I am obliged to state to you, that instruction in the theory, as I conceive it, will be extremely difficult, unless I can show by drawings at large scale, by very visible drawings, what I desire to say to you, for you cannot have absolutely all the edifices in memory, of which I shall have to speak.

You see with certain reserves what I can state will be the programme of my course. Further, I do not desire to restrict myself to a table of contents prepared in advance I have to study and try everything, to seek with you; I request a little credit, offering you in pledge good will that you cannot doubt.

The course in Theory, or rather the functions of the professor of Theory, comprises another important question, that of the programmes, of such importance, that I voluntarily say, and this I believe to be your own opinion, that especially by the preparation of the programmes can the professor of Theory have a durable and permanent effect on your studies. Because of this capital question I have desired to present before you this inaugural lecture, before you have received the first programme signed by me, because I have something to say on that subject, and you may perhaps feel some surprise next week on receiving programmes, that may differ to a certain extent from those you are accustomed to receive.

To make a good programme is difficult, and very difficult to make a good series of programmes. There is required a system, a sequence of ideas; a constant attention to the general state of studies in the School, and care to direct them to that side on which exist gaps and deficiencies. Yet with all these reserves, I will state my mode of thought.

Gentlemen, I believe that in our School the distinction between the first and the second classes has been gradually effaced too much; perhaps it has been lost out of view, that the first class is that of composition in particular, that the second class is one of preparation by all the studies [illegible] special professors, that you follow and agree to pursue with the greatest care a preparation from the architectural point of view, first by analytical elements and also by studies of rendered projects. We have seen [illegible] programmes given alternately in the first and second classes, or indeed in the first class the project was a little more important; but the difficulty of a programme is not measured by its importance, or by the area covered; and I do not see, for example, why a city hall for the chief city of a district is an easier programme than one for the capital of a department. Then in accordance with this idea of preparation just mentioned, I understand the programmes of the second class as being preparatory to composition. First I will consider and present to you in regard with me the programme of analytical elements as corresponding to this first portion of the course in theory explained to you, the elements of architecture.

After having held several competitions in the analytical elements, I desire to look about you, and profit by this community of studies, which is the grand impulse and even the life of the atelier, that you may know [illegible] your professor, that he himself considers in the first class, does not have to say to you:--"Then learn how to make a [illegible] or a [illegible]!" Tell yourselves distinctly, that the purpose of these competitions is not to make you copy details in [illegible]; it is the primary grammar, the knowledge of the materials of your future studies, [illegible] subjects for complete studies will be the [illegible].

As for the competitions in rendered projects, classed in the second class, by [illegible]--and it is absolute [illegible]; for there cannot be anything absolute in making drawings--it [illegible] simple subjects, where [illegible] do not have too many chances to be bad, except by one of those phenomena of good invention [illegible] foresight; finally, nothing is more painful for the student

Gentlemen, I believe that in our School the distinction between the first and the second classes has been gradually effaced too much; perhaps it has been lost out of view, that the first class is that of composition in particular, that the second class is one of preparation by all the studies confided to special professors, that you follow and agree to pursue with the greatest care a preparation from the architectural point of view, first by **analytical** elements and also by studies of rendered projects. We have seen certain programmes given alternately to the first and second classes, or indeed in the first class the project was a little more important; but the difficulty of a programme is not measured by its importance, or by the area covered, and I do not see, for example, why a city hall for the chief city of a district is an easier programme than one for the capital of a department. Then in accordance with this idea of preparation just mentioned, I understand the programmes of the second class as being preparatory to composition. First I will consider and request you to regard with me the programmes of analytical elements as corresponding to this first portion of the course in Theory explained to you, the elements of architecture.

After having held several competitions in the analytical elements, I desire you to look about you, and profit by this community of studies, which is the grand impulse and even the life of the atelier, that you may know these elements so that your professor, even as occurs sometimes in the first class, does not have to say to you:--"Then learn how to make a doorway or a window!" Tell yourselves distinctly, that the purpose of these competitions is not to make you copy details in books or to merely exercise you in washes; it is the primary grammar, the knowledge of the materials of your future studies, restricted subjects but complete studies will be the programmes.

As for the competitions in rendered projects, always in the second class, my intention is-- not in an absolute fashion, for there cannot be anything absolute in making progress-- to generally give you simple subjects, where sketches do not have too many chances to be bad, except by one of those phenomena of good intentions whose secret you have, and that foils al foresight; finally, nothing is more painful for the student

and the professor than to be tied for two months to a sketch, that cannot be made to live. When you return from the competition with one of those sketches, allow me to say, when one knows not by which end to take it, the role of your professor becomes horribly thankless and painful, and the student applies his good will and labor to something fatally abortive. There is indeed a certain result from the studies and an advancement, but on the contrary is the risk of disgust and discouragement. On the other hand, I desire these programmes of the second class to be of a nature to initiate you into more profound study, and that you have seen well what has been seen; in brief, not to look so far, but to proceed more surely where the second class may lead you, so that the passing of the threshold of the first will admit you well prepared, like men already with an equipment of studies, and for whom the studies, from which result the final competition, will have few secrets.

But I desire to make for the sketches something analogous to what very properly occurs in the sections of painting and of sculpture. You see your comrade painters admitted here; they have passed tests for admission and enter the School. Is a painting required from them? No. They are required to study nature and the antique, to learn how to draw a figure, and this takes a long time. But at the same time to accustom them gradually to composition, not to make paintings but sketches. This is excellent, and I shall very willingly give you in the second class programmes of composition as programmes of sketches, to accustom you to compose, to prepare you for the first class, saying to myself in regard to a defective composition on which you have spent twelve hours, that those twelve hours have not been spoiled or lost, but spent if you will, and at most you will not be tied for two months to a composition incapable of life.

As for the first class, it appears to me that as the student learning a language first studies grammar, then attempts little translations, finally attaining to speaking or a volume, you will be exercised in accordance with the method necessary to your studies;-- knowledge of the elements of architecture, of the elements of composition, and finally of composition itself.

I have desired to say this to you, because next week you

will receive programmes; these will be my beginning in making school programmes, and the students in the second class will find themselves before a programme for the composition of an edifice, so that I do not wish them taken by surprise. You know this, gentlemen, so prepare for it.

A further word, gentlemen. Whatever the programme made by me, you must add something to it. I cannot repeat diffusely what goes without saying, that you must read between the lines and words of the programme; besides the always dry naming of the requirements demanded from you and the needs to be satisfied, there is this understanding, this postscript, which like all postscripts is frequently more important than the body of the letter; it is that all you do must be a work of art, must be composed and studied with the love and passion of art; that among us all that lacks art, and artistic research does not count. Our programmes are prosaic; they can scarcely be otherwise in their form; it is for you to add to them poetry and your youth, which I can no longer do.

Ah! my young hearers, do not bankrupt your youth; it will not last too long! Believe fully that perseverance is the great lever of all studies; that you should have an elevated idea of your art, for it merits this; and believe in the future of our art, which is your own. Gentlemen, possess those virtues without which there are no artists, will, pride and faith!

## CHAPTER 2. DIRECTING PRINCIPLES.

SUMMARY. -- Freedom from numerical formulas. -- The beautiful in architecture and its identity with truth. -- Method of composition in architecture, from general to details. -- The programme. -- Location, ground, surroundings, climate. -- Truth in construction expressed by architecture. -- Artistic falsehoods. -- Material stability and the appearance of stability.

My inaugural lecture may be summarized briefly; I have sought to make you see the entire elevation of your studies. If you left that session with more elevated feeling, more ambitious thoughts, my time was not wasted.

Today I propose to explain to you -- as far as possible -- the general principles that should always govern your studies. I desire you to perceive for yourselves the unity of these studies apparently so diverse. You exercise today on a church, tomorrow on a theatre; your programmes are sometimes austere, sometimes worldly; your sites are limited and enclosed within a city, or free and airy in the country; this variety is necessary to create in you flexibility and ingenuity; but beyond these studies of the present day and hour is the higher and permanent study; that of your art in all these cases, and of yourselves. This study is the real purpose, and it is the unity of your labors; it is the domain of the principles mentioned, which will be your guides, salvation and light.

First to open our path, let us begin by a little clearing.

There is no need to tell you, that I am not an enemy of the antique orders, whether there be three, five or even four. But I have always been shocked to see those antique orders placed at the starting point of studies, when the student is still unable to understand them, and particularly by authors that only seek and find one form, i.e., an expression and not a conception. I hope to show you that the orders are more valuable than their commentators, and the sauce with which they are served. But I cannot see them as the sole pivot of architecture or the first stage of your studies.

Yet for more than two centuries, architectural studies have been subject to this despotism. When the Renaissance, in that grand movement of the human mind that renewed philosophy, literature, sciences and arts, gave its admiration and enthusi-

asm to the grand monuments of antiquity, it admired them without limits indeed, and yet without sacrificing itself. It was inspired by them, but knew how to remain the Renaissance, that springtime of history, the Renaissance so full of sap and so ardent for liberty, that even when it believed itself copying, it impressed on its masterpieces the stamp of its own art and of its vivid independence. But it had its theorists and writers, who desired to recover the theory of the marvels it admired; they questioned the ruins, but unfortunately-- I say this very distinctly --they found one named Vitruvius.

Vitruvius was certainly a mediocre writer and probably a mediocre architect, if he was indeed an architect, leaving a book very subject to discussion, a collection more or less conformed to the rules of Grecian architecture; very far removed from the origins of that art, he was to the creators of architecture just as were the rhetoricians to the great orators, and the sophists to the great philosophers. But as an ancient writer on architecture he alone survived, and criticism was not then born; the 16th century took him at his word, just as it then believed anything written in Latin; the authors of the Renaissance, Alberti, Vignola, Palladio and Delorme, all great artists, followed him in the path of computed architecture, the genius of the Renaissance alone remai ed free in spite of all, and the art was superior to the inst tion it received.

But later under the aged Louis XIV, when the great thinkers of the first half of the 17th century had disappeared, the French spirit was transformed; to bold independence had succeeded superstition for authority, narrow devotion to rule, the veneration of despotism. There remains a curious deliberation of the royal Academy of Architecture, then just created, which proclaimed the supremacy of Vitruvius, and in some sort made him a father of the artistic church. Then his theories b came almost royal, and the triumph of the module was almost a article of faith. The module or controversies on it held a great place in instruction, and singularly figures became sovereign in the domain of art. In spite of the sturdy independence of the true artists of all time, in spite of the temporary and so brilliant Renaissance of Gabriel and his rivals,

figures strengthened their tyranny until very recent times. Again today some persons believe architecture to be a computed art, a manual of rigid and mathematical formulas!

No indeed. --Architecture is not a science of numbers, and if necessary to prove this, I would prove it by one word, art Otherwise it would be unnecessary to teach here! On the contrary, I shall soon show you that the delicate sense of proportions is nothing more than the faculty of perceiving their infinite shades; this freedom in study is even the honor of the artist, for it is likewise the danger, the condition of the glory of the triumph.

I shall speak of the antique orders, certainly with respect and admiration, but in their time and place. The first architects that erected colonnades -- and it was assuredly bold-- had previously built walls, in these walls being doorways and windows. If the study of the orders then reacted on these elements, it is no less true that this was only possible afterwards. This is the logical method; to commence the instruction with the orders is to instruct in the appearance; to begin with the wall is to instruct in the reality.

I return to the principles.

Science has its axioms; art has its principles. Both are the basis of our studies. Of all the arts, architecture is that with the most rigorous principles; but like axioms, principles are not demonstrable, unless by the eternal superiority of the works, that have most faithfully respected them. The constant conformity of the works to the principles produces the great artistic epochs, that merit the fine name of classical; whose works are worthy of thought and study, that transmit to us by elegant examples even the conscience of art during the ages.

Principles are not a restraint but a light; they are also the nobility of an art, the viaticum and the watchword of artists. And if this be always true -- the more you study the more you will be convinced of it, -- it is doubly true for the studies. Later a detached personality or accidental necessities may sometimes advise deviations and compromises. During the studiea and for them, the principles are inviolabl

Let us examine those which should guide you, that concern the first attempts or the higher studies.

The beautiful is the splendor of the true, said Plato in a magnificent definition. Art is the means given to man for producing the beautiful; art is then the pursuit of the beautiful in the true and by the true.

In the imitative arts, the true is nature; in the creative arts and notably in architecture, the true is less readily defined; as for myself, I shall express it by the word conscience. If for the painter and sculptor, the true is in the external world, for us it resides in ourselves.

In ourselves, provided we know how to loyally question ourselves. Then seek that intimate and profound truth, that verity of conscience. Thus you will protect yourselves from the contagion of ephemeral success, from the tyranny of fashion, from servile imitation, from the mirage of thoughtless fancy.

Besides you will have safe guides, if you have the will to follow them. I will endeavor to indicate them to you.

The ancient authors recognized three divisions in the work of the architect.

The arrangement, which we call composition.

The proportions, that is the study.

The construction, the control of the study by science, and finally the erection.

Composition cannot be taught and can only be learned by repeated attempts, examples and advice, personal experience superposed on the experience of others.

Furthermore, if for the study the experienced artist is nearly certain of his powers, the part of daily good fortune in composition is great. For the same subject, some will make a find today, who found nothing yesterday and will find nothing tomorrow.

But remember this carefully, for it is even the reward of your studies; this fleeting and doubtful idea offers nothing except to the strong; if it comes to you when you are well prepared by strong and serious studies, you will know how to use it; you can compose; if by a miracle it appears to the ignorant, he will allow it to escape or will torture it without any result.

Thus to compose is necessary the idea, and that is a good fortune; the power from studies is required, for this is the

certainty of using the idea.

This idea will rarely be the result of a series of reasonings; it will most frequently be synthetic, rising in its entirety in your minds; this mode of creation, that baffles the theories and methods of traditional logic, that contradicts Bacon and Descartes, is intuition, the true generator of the artistic ideas. And the procedure will be the same, whether the subject be restricted or immense.

Indeed in the most extended programme, you first omit the details in order to perceive only two or three, perhaps four or five great groups of varied importance, conceiving the relative proportion of each. Which should have the dominating position, and which the greater or lesser extent? All these are questions of the programme and an understanding of the needs and the effect. Passing from the entirety to the parts, from the mass of the building to its details, you readily progress if your chief starting point be judicious, especially if it is found, reserving if necessary for later study many details to give credit to the composition, provided it presents sufficient materials and the limits are propitious.

Reasoning and criticism, which I neglect in nowise, will come in their turn to control your conception, for after you have conceived, you must know how to be the proper judges of your conceptions.

In your compositions you will first be guided by loyal fidelity to the programme. This should not be the work of the architect, but should always be given to him; each one has his own part. The architect is the artist able to realize a programme, but it is not for him to decide if the client needs one or several chambers, whether he requires or not, stables, carriage house, etc. (Familiar examples are here assumed). It is very true that frequently the architect receives no programme, and many of our more important edifices have been erected without a programme. It is very sad, and do you know why it occurs? It is because that three-fourths of the time clients or officials do not know what they want. Yet this is for them to know and not for us.

At least it will not be so here, for you will receive programmes. I assume them to be properly made, this assumption not exceeding my right. It belongs to you to know how to read

them properly.

A programme gives you a list of the rooms, indicates their relations, but suggests neither their combination nor proportions. That is your business; the programme should still less impose solutions, and I have never conceived such restrictions. Just as well hold your hands. The programme leaves you liberty of means, but you must understand well what is expected from you; you must have a just idea of the proportions of the different parts, and it will often happen that the important and capital thing will consist in one word, while a paragraph is necessary for the minor accessories. Read it with your intelligence and good sense.

But further, there is still the relation of the programme itself to the entirety of architectural programmes. You have an easy tendency to exaggeration, and we see in your compositions arrangements on the scale of St. Peter in Rome for little court houses. Error in proportion and taste. There are great, medium and little programmes; place yourself at the scale, for only thus will you attain variety in truth, i.e., character.

The programme indicates to you an essential element of the composition; the location and ground. Architecture has many domains; the cities with all their diversity of sites, the country with its landscapes and surroundings, the seashore and the mountains; very different latitudes without leaving France.

In a city like Paris, monuments are generally placed on monumental locations, though not invariably. Evidently a programme for a ministry of marine will be the same in whatever quarter, and yet it would be quite different to assume it located on Place de la Concorde, or on a street. The Pantheon would doubtless be entirely different, were it not on the top of the hill of S. Genevieve, and one would not conceive the Court of Accounts in the architecture of the old Palace d'Orsay, had it not an outlook on the Seine and the Tuileries. Yet Paris is almost a level city. If you dwelt in an amphitheatre like Genoa, your eyes would behold what you can alread find in the owrk of Gauthier, all programmes receiving in turn an original and local solution for that very peculiar situation of the city.

In the country, there should be felt in your compositions an endeavor for outlook and air. There is always one side very different from the others; and it may be said, that the plan of every country house is composed with special reference to the preferred view.

If the ground be somewhat sloping, this serves for the most beautiful views [illegible] with the [illegible] of [illegible] [illegible] the compositions. If [illegible] you require [illegible] circumstances with symmetrical arrangement, it is only by a horizontal plan or level lines that these can be realized without [illegible] [illegible]. Thus it means a monastic structure like the celebrated Abbey of Monte Cassino, a hospital like Charenton (Fig. 21), a garden as at S. Germains, Meudon, or the Villa d'Este at Tivoli (Fig. 22), or the [illegible] of the [illegible] at Rome, the ground [illegible] composition in successive levels, as if for the steps of a stairway.

The greater the inclination, the more imperious is this law; even more so on a mountain than on a simple shore.

At the seashore one seeks protection-- like the permanent inhabitants-- or enjoyment as transient guests. Compose accordingly and for hotels, villas or casinos, remember that [illegible] with a view of the sea. This is the sole reason for going there.

The programme will simply tell you, that the structure will be on a certain ground or site; it is for you to understand all the results of such [illegible] and so utilize it for the variety of your studies.

Assume two identical programmes with the same importance and requirements, one in the North and the other in the South, and [illegible] the studies and the compositions entirely differ. In the South [illegible] [illegible] [illegible] will protect yourselves from the sun, which you will seek in the North. In both climates architecture has entirely different needs; it is very remarkable that architects of the 16th century in France, so passionately fond of Italian architecture, and even Italian architects working in France [illegible] borrowed from Italy the taste, forms and decorations, but not its composition.

In the country, there should be felt in your compositions an endeavor for outlook and air. There is always one side more attractive than the others, and it may be said, that the plan of every country house is composed with special reference to the preferred view.

If the ground be somewhat sloping, this search for the most beautiful view competes with the requirements of construction to dictate the composition. If indeed you require extended structures with symmetrical arrangement, it is not by a horizontal plan or level lines that these can be realized without great substructures, enormous fills and excavations. When it means a monastic structure like the celebrated Abbey of Monte Cassino, a hospital like Charenton(Fig. 21), a garden as at S. Germains, Meudon, or the Villa d'Este at Tivoli (Fig. 22), or the promenade of the Pincio at Rome, the ground requires composition in successive levels, as if for the steps of a stairway.

The greater the inclination, the more imperious is this law, even more so on a mountain than on a simple shore.

At the seashore one seeks protection-- like the permanent inhabitants-- or enjoyment as transient guests. Compose accordingly and for hotels, villas or casinos, remember that you cannot have enough rooms with a view of the sea. This is the sole reason for going there.

The programme will simply tell you, that this structure will be on a certain ground or site; it is for you to understand all the results of that brief phrase and to utilize it for the variety of your studies.

Assume two identical programmes with the same importance and requirements, one in the North and the other in the South. Not merely the studies but the compositions entirely differ. In the South will be rooms lighted indirectly from beneath porticos, preferably opening on shady internal courts; you will protect yourselves from the sun, which you will seek in the North. In both climates architecture has entirely different needs; it is very remarkable that architects in the 16th century in France, so passionately fond of Italian architecture, and even Italian architects working in France like Boccador, borrowed from Italy its taste, forms and decorations, but not its composition.

I have cited Boccador, i.e., the City Hall of Paris; see on the facade those immense windows with the entire height of a story (Fig. 23) nowhere found in Italy; need of light at Paris, protection from sun at Florence or Rome, as at the Capitol of Rome, that has become a city hall (Fig. 24). It is interesting to compare two monuments of very great worth and almost contemporary, the court of the Louvre (Fig. 25) and the Cancellaria Palace at Rome (Fig. 26). The court of the Louvre is fully inspired by Italian art in study and decoration. But see at the Louvre the proportions in height of windows compared with those of the Cancellaria. With the facade of the Cancellaria in Paris, one would not see distinctly, but at Rome with the facade of the court of the Louvre, one would be blinded and burned.

And these are not slight differences, for taking the figures.

Total surface of one facade is:--

| | |
|---|---|
| Cancellaria | about 958 sq. ft. |
| Louvre | about 1269 sq. ft. |

Total areas of the openings are respectively:--

Cancellaria, about 113 sq. ft., or 11.8 per cent of surfa
Louvre, about 245 sq. ft., or 20.9 per cent of surface.

The windows of the second story have heights of:--

| | |
|---|---|
| Cancellaria, | 9.2 ft. |
| Louvre, | 15.1 ft. |

Taking the wall spaces between windows, we find on the contrary:--

| | Bet. Ground and 1st. | Bet. 1st and 2nd. |
|---|---|---|
| Cancellaria, | 12.1 ft. | 16.4 ft. |
| Louvre, | 10.8 ft. | 12.8 ft. |

Finally, the total height of openings on each facade and its ratio to total height of the edifice are:--

| | Total height. | Total windows. | Ratio. |
|---|---|---|---|
| Cancellaria, | 80.0 ft. | 28.2 ft | 35%. |
| Louvre, | 74.7 ft. | 40.3 ft. | 54%. |

Certainly there is to be learned a lesson from this comparison, not given by myself, but by the great artists of the 16th century. What errors have resulted from having forgotten or scorned it?

Another guide for you will be truth of construction expressed by the architecture. Here I perhaps touch upon the most elevated of all your studies.

Until [illegible]-le-Duc said that architecture is the art of [illegible] ing.--This was a militant definition, a protest against too real disdain of construction in certain schools of [illegible] time. But to be more incisive, that definition was incomplete and itself sinned in forgetting artistic composition. Architecture conceives, then studies, finally constructs.

But, and this must be fully understood, construction is the final purpose of composition and of study, for [illegible] conceives or composes except to be able to construct. And construction should be the constant thought of the ar[illegible] for it supplies the arsenal of his resources and also limits his domain. All tentative architecture not constructed does not count, and every architectural form that violates or falsifies the construction is vicious.

And if by the word construction you understand ever the structure of the edifice, its entire and effective reality, you conceive that the completed edifice expresses nothing other than that structure, that the construction [illegible] existing not like [illegible] at all, yet such still [illegible] are also falsehoods in architecture-- and unmistakable [illegible]

What would you say of the facade of a house, that [illegible] four stories, when there are but three? [illegible] you will think-- and indeed the house is [illegible] that falsehood by its incongruity. Yet are you [illegible] this does not exist elsewhere?

Well in Paris itself -- for I prefer if possible examples that you can verify -- see the facades of [illegible] or of Ss. Paul and Louis. Each shows three stori[illegible] Each presents an [illegible] nothing in common [illegible] facades produce the effect of planes [illegible] foreign to the monument, that they disguise instead of [illegible] Likewise in Italy are numerous facades, [illegible] cite the Cathedral of Lucca, with so interesting [illegible] them", see the facades of other churches, [illegible] Champs, the transept facades of S. Eustache, [illegible] elevated of all your studies.

Henri Labrouste taught that architecture is the art of building.--This was a militant distinction, a protest against the too real disdain of construction in certain schools of that time. But to be more incisive, that definition was incomplete and itself sinned in forgetting artistic composition. Architecture conceives, then studies, finally constructs.

But, and this must be fully understood, construction is the final purpose of composition and of study, for one never conceives or composes except to be able to construct. The construction should be the constant thought of the architect, for it supplies the arsenal of his resources and also limits his domain. All tentative architecture not constructable does not count, and every architectural form that violates or falsifies the construction is vicious.

And if by the word construction you understand even the structure of the edifice, its entire and effective reality, can you conceive that the completed edifice expresses anything other than that structure, that the construction expresses anything but itself? Not at all, yet such still exists, there are also falsehoods in architecture, and sometimes with the perfidious charm of great talent displayed in falsifying. What would you say of the facade of a house, that indicates four stories, when there are but three? A ridiculous question you will think-- and indeed the house is guaranteed against that falsehood by its impossibility. But are you certain that this does not exist elsewhere?

Well in Paris itself -- for I prefer if possible to cite examples that you can verify -- see the facades of S. Gervais or of Ss. Paul and Louis. Each shows three stories. -- Why?-- Each presents an outline having nothing in common with the construction of the edifice, so that if viewed sidewise, these facades produce the effect of planes isolated in space, foreign to the monument, that they disguise instead of indicating. Likewise in Italy are numerous monuments, among which I will cite the Cathedral of Lucca, with an interesting facade entirely out of accord with the structure(Fig. 27). On the contrary, see the facades of other churches, S. Nicholas--des--Champs, the transept facades of S. Eustache, S. Etienne du-Mont and S. Laurent; with sensible differences in style and

taste, even the structure of the monument appears; all is logical and sane. Falsehood on the one hand, truth on the other.

Again a falsehood -- perhaps absolved by the glory of the triumph --is that colonnade of the Louvre, those facades of the Louvre from Louis XIV, without harmony with the interior, and which later required the addition of a third story next the court of the Louvre, happily designed by Gabriel(Fig. 28). It is indeed a beautiful front, a fine ornamental page; but how much more beautiful and admirable, had Ferrault known how to produce the same effect without violating and nearly compromising a monument certainly not meriting such disdain!

If the antique were invoked so erroneously by the authors of these artistic falsehoods, it never made them; this is its purest glory and esthetic superiority, and also-- since we are in the School--its educative superiority. Search through all antiquity and you will not find a single edifice, whose interior and exterior are not reciprocally the result of each other. When you have once comprehended the structure of an antique edifice, its form, expression and realization arouse in you the absolute idea of necessity. This must be so, and that could not be so. At the same time it is generally very beautiful. but beautiful by composition and not by artifice. There is perfect art.

But is this the privilege of antiquity? No. The same sincerity, identity, impression of "that could not be otherwise", I find in the first basilscas, in our churches of the 12th, 13th and 14th centuries, in our Northern city halls, in the palaces of the Italian Renaissance, in our beautiful modern edifices; perhaps less pronounced and less evident, less glorified by that sovereignty of the master, which in thw arts as in literature seems to be the mark of antiquity,--perhaps because of the simplicity of its programmes.

Such is the true aim and the elevated purpose of our art. Indeed our life has complications, and our programmes have requirements, that do not lend themselves to abstract art. Yet a noble thought is the beacon of art; it is not attained and is beyond our reach; but only by its direction can we follow the assured path without deviation; let us give ourselves that ideal of the beautiful epochs, for it will not be to copy them, since this ideal is the entire sincerity of a conscientious

art, seeking perfection only with its own means and its own needs, which cannot be perfect if it be not entirely its own evidence and its own inspiration.

But for this noble artistic impression to be felt, it does not suffice for its stability to be real, but it must be evident. Admiration in art is a real benefit, an entire satisfaction, while astonishment does not occur without anxiety. Thus evident and incontestable strength seizes on the mind more than the surprise; admiration is reserved and conviction is first necessary.

These two impressions are very apparent on the same monument, Notre Dame in Paris.

When we see the principal façade(Fig. 29) with its monumental towers, its portals so well enclosed, the clear lines of its twi galleries, you admire the monument with its magnificent sanity; no accidents or freaks, even the centuries cannot destroy or even injure that entirety so well posed and so strong in its proportions; there is entire satisfaction and no anxiety, and if this feeling is not analyzed, it is still effective; you admire with felicity, giving yourselves up entirely.

Pass around and observe the chevet of Notre Dame(Fig. 30). What you now see requires more science or experience and more fortunate boldness. One scarcely conceives how these forms and reactions, thrusts outward and inward, can be equilibrated The monument appears like a vessel on its ways for launching, supported by struts, and the mind asks what would happen if a shock or a crushed stone endangered the astonishing equilibrium. Astonishing indeed, but artificial and precarious in comparison with that marvellous principal facade, so majestic in the evidence of its unshaken strength.

## CHAPTER III. THE GRAND RULES OF COMPOSITION.

SUMMARY. -- Useful areas and communications.--Economy in composition. -- Lighting and aeration. -- Easy removal of water. -- Determination of importance of the parts of the programme in view of the arrangement. -- Sacrifices. -- Useful arrangements and beautiful arrangements. -- Symmetry. -- What is to be understood by a beautiful plan. -- The picturesque.-- Variety. -- Character. -- Character a condition of diversity. -- Tradition. -- Effect of social conditions on the architecture of each epoch.

Let us condense somewhat the requirements of composition. In every programme as soon as it is complex are two distinct parts; first, what I shall term useful areas, then the necessary communications. To take from this consideration its slightly abstract character, take a familiar example, a house; select if you please the plan of a great mansion of the 18th century (Fig. 31).

The useful areas here are all the occupied rooms, which are enjoyed and required by the occupant. We build to have salons, dining rooms, chambers, closets, kitchens, etc.

But to connect all these and permit access are required the necessary communications; horizontal, by means of galleries, corridors, anterooms, entrance spaces; vertical, by means of main and service stairways. That is inevitable, as well as courts for light and air in the dwelling; such areas cannot be termed useless, because they are necessary but are not occupied, and without being the object of construction are a necessary condition; they may properly be compared to the general expenses in the industries.

Just as in the industries, the general expenses must be reduced as much as possible, so in architectural composition must be restricted as much as possible the areas devoted to communications. This is the intelligent economy of the artist. But remember this.

I do not wish to say that your stairways must be mean, your galleries or porticos narrow, far from that; but do not uselessly multiply these means of communication, all useless communications became embarrassing and even obstructive. Generally the chief difficulty in composition is to arrange to easily pass everywhere, that all parts may be conveniently

connected and the simpler the means found for this, the clearer and more fully understood will be the plan. Ensure the communications but without excess of porticos, galleries, etc. Here in particular is to be recognized simplicity as an exquisite quality of composition.

From this point of view, see the magnificent plans of the Baths of Caracalla, the Invalids, Palace of Justice(Fig. 32) and the City Hall of Oaris; you will be struck by the simplicity of the means by which the architect knew how to ensure the communications withour meanness. On the contrary, they are more simple, and you are authorized to give magnificence to such proper communications.

Another considerable difficulty is that of lighting all parts of a composition. One must always reject the too convenient custom at the beginning of the 19th century of providing lighting from overhead. Consult on this point the very curious volume of the collection of grand prize designs--curious as examples not to be followed. You invariably see there compact plans with at least three and often four or seven widths of adjacent buildings, all these possibly only lighted by skylights in the roofs. No aeration possible, and suffocation is assured; strangely a bitter struggle or the disapperarance of that generation was required for the window to be tolerated in composition, while awaiting its recognition as necessary. Whence came that error? This would take too much time to show; I mention it to warn you, that you still suffer from it; even today you sometimes project audience halls lighted by skylights, a pure monstrosity.

Remember thatwe must have light and air. Vertical lighting is good in special cases, as for the halls of museums; tolerable in some circumstances, when impossible otherwise; but all these are merely exceptional, and save exceptions, use windows!

This consideration is also combined with another, no less essential, the easy removal of rainwater. A good composition necessarily lends itself to a rational plan of the roofs, so made that the water may be easily and certainly removed, avoiding all internal down pipes and long gutters for water. You do not always study your roof plans, but your ground floor plan fixes them and may show their complexity or even impossibility. Observe the plan of the Invalids (Fig, 41); this plan

of the ground floor suffices, and you need no roof plan to prove the easy removal of the water. This plan is not ingenious, but is better as having no need of ingenuity. How it facilitates a clear and easy composition of the roofs (Fig. 33)! Simplicity always!

In what order will your plans of different parts of a composition be made? Here are no rules but good sense, understanding of the programme, and the most thorough knowledge of the requirements. Composition is only a series of sacrifices. In every plan is a place more in view, more central, the chief place. For this principal place parts are not lacking, to which shall it be given? That depends on many things.

Observe the Palace of Versailles(Fig. 34). The chief place of honor is well marked in the centre of the marble court, in the middle of the projection toward the lawns of the garden. Mansard placed there the royal chamber and the grand gallery for receptions; the chapel is placed in a wing, magnificent, but really sacrificed to the royal majesty. Yet Louis XIV was a very Christian king, yet first of all was the King.

On the other hand, see the Escurial (Fig. 35); the chapel is there the centre and heart of the composition, all converging toward it. Yet Philip II was the king of that realm on which the sun never set-- but before all a Christian king.

Architects have occasionally understood-- perhaps hinted -- what must be put in the first place, and what must be sacrificed.

In every composition are sacrifices, that one must know how to proportion or graduate. In the secondary parts or stories must be judiciously placed all that should yield to the principal parts. And just there does the architect incur so much criticism; he can scarcely avoid objectors, who carefully avoid basing their objections on personal interests. Oh no! It is merely a general interest that inspires them-- and also secretly the fact of being lodged in the 5th story on a service court.

Everything just said is related to a judicious, economical and useful arrangement.

But this is not all, and we are not utilitarians. A people that sees only the useful in architecture without also desiring to see the beautiful, renounces all civilization; Beule

wrote a singular essay, in which he shows that the Spartans -- the men of the black broth-- had and desired an art, but they also wished to conquer thw Athenians. And I believe this, since otherwise they would merely have been savages.

Your compositions must then be controlled by another consideration of beauty. This is the undying principle, that the useful is pleasing.

Is it necessary to define a beautiful composition? It will first be good, but it will also ensure a good appearance. Your salons will each be doubled by the total effect, if you know how to arrange beautiful perspectives; your courts, if prolonged by skilfully managed views; your facades, if arranged with fine projections, accented recessions or pavilions, energetic or elegant outlines; if all that is varied and you have contrasts; and briefly, if you know how to be artists in your composition. I could cite a very great number of compositions well indicating that care for beauty; all actually exhibit this. I will indicate but a few examples; the House of Panza at Pompeii (Fig. 36), Palace Barberini at Rome (Fig. 37) and the Abbey of Monte Cassino (Fig. 38); there is only embarrassment in choice; these examples suffice to show what is a composition, that occupies itself with beauty of appearance and a wise succession of perspectives.

Symmetry, but with variety, should generally be sought. But it is well to define symmetry.

Symmetry is the regularity of what is seen at a single glance; symmetry is intelligent regularity.

I have just mentioned the first volume of the grand prizes. You will there find a great number of plans thus arranged; a longitudinal and a transverse axis divide the plan into four quarters, that may be exactly superposed; not a pilaster more or less. That is not symmetry but nonsense.

The City Hall of Paris has each facade symmetrical; that is a beauty, but the facade on the Quay does not repeat that on Rue de Rivoli; this does not lessen symmetry, any more than the difference between the principal and rear facades. On the contrary, this variety is another beauty. Versailles is symmetrical at a glance, but not actually so, and the same with other monuments.

Symmetry is incontestably a beauty, and monumental compo-

sition can rarely renounce it without detriment. That is again a rule in composition to be heeded. From you is generally required but one facade for a project, and you will consciously foresee that one with or without symmetry; but the others are not studied and are implied in your plans; side and rear facades, those on courts, all at least may be studied. In composing your plans, all these are to be composed.

This leads me to discuss this phrase, "a beautiful plan"; This is concise, and one must understand by it a plan, that permits and promises beautiful interiors and facades. Some forty years since were freely mentioned plans beautiful in themselves without regard to all the rest. Outlines of plans were spoken of, as almost symbolism in horizontal projection. The type of this bathos is the plan of ~~the~~ a Palace of the Legion of Honor with five projections forming a star, and a circular hall at the centre, just what Prison Mazas was to realize some years later.

Indeed there are beautiful plans and the expression is quite legitimate, but just like books, beautiful by what is read therein, or a musical score, beuatiful by its contents, and not by the arabesque appearance of the notes.

To the general appearance of the composition and particularly to symmetry is freely contrasted the picturesque. Thus the Palace of Justice in Paris justly passes for one of the picturesque elements of the capital, with its Palace of S. Louis, of Horloge, its waiting hall, and the S. Chapelle in the midst of its buildings of the three or four last centuries (Fig. 39).

I adore the picturesque, and certainly the picturesque most strongly strikes the foreigner arriving in the city.

But one does not compose the picturesque, which is only composed by the works of the greatest artists and by time. Seven centuries have labored and made their imprint on this Palace of Justice; who would dare to flatter himself with doing all that alone and in a day? One composes the Place de la Concorde, when one is an artist of genius, but neither the Place S. Mark of Venice, the Place Signory in Florence, that of Siena, nor the Capitol of Rome. (Fig. 40).

I go farther; do you desire the picturesque? Do not seek it. Not thus may you perhaps have it. The last centuries in

completing the great edifices of the past did not feel restricted to a dead sytle; the Palace of Justice was continued without making it 13th century, and the Palace of Justice is picturesque. At Notre Dame and many other churches, you find successive styles from the 12th to the 15th centuries--and Notre Dame is picturesaque. Nothing is more so than the interior of the Cathedral of Toulouse with the lack of coherence of its two parts, which is again an archaeological anachronism.

But what then is actually the picturesaque?

Variety. And does not this variety depend on us architects, which we can provide and ought to ensure?

This legitimate variety is nothing else than character, the identity of the architectural and moral impressions of the programme.

Doubtless there is an intrinsic beauty of the programme; we admire the superb vestiges of monuments whose purpose is unknown to us. But beauty is not a commonplace quality, and the search for it has no right to dispense with character. The magnificent forms of a palace would be ridiculous if applied to a prison; applied to a school or industrial structure, they would be out of place.

The character of edifices is then a condition of their diversity, and preserves a city or a period from monotony of structures. The architect must at need adopt abnegation, and also resist temptation.

The search for character is further a relatively modern conception. Antiquity has many edifices clearly characterized, but id does not seem to have made character a chief merit; thus the Parthenon, temple of the Athenian deity, and the Propyleum, the military portico of a citadel, present the same elements; likewise the halls of the Baths and the Basilica of Constantine. With the middle ages and the Renaissance, continued by modern architecture, character is more impressed on churches, Monasteries and convents, whose architecture is so special, also on city halls, palaces, then on administrative, judicial and educational buildings.

This is not surprising, being the confirmation of a frequently stated law. Since the Christian era, men have become more varied and also more complex; let us not complain, for diversity of character in our edifices is a cause of attraction,

and another possession of the language that we speak.

Finally, to sustain amd guide you, there is tradition. I know that to speak of tradition one passes for being behind the time; it is a present tendency to scorn tradition. That is to despise long efforts continued through centuries by the industrious generations preceding us. Generally, this is to seek to conceal ignorance by affecting to scorn the unknown in order to avoid the effort necessary to know it.

Preserve yourselves from this error. Progress is slow and must be sure. Whoever proceeds slowly is sane, and whoever is sane goes far.

Do you know what is very strong and original? It is to do very well, what others have merely done well.

The finest epochs are those in which tradition was most respected, when progress was continuausly perfecting, evolution and not revolution. There neither is nor has ever been spontaneous generation in art; between the Parthenon and the temples preceding it are only shades of difference.

Furthermore and especially for studies is tradition precious. To dare to become free from it, one must judge it, and to do this, it must be known. Tradition is a paternal patrimony; to dissipate it independemtly, one risks finding himself wandering at random; at least one must know how to ensure himself of another shelter.

This seems to be what may be said in general on composition; let us summarize it.

You must be faithful to the programme, be permeated by it, and see properly the proportions of the programme and the scale to be observed.

The location entirely varies the expression of the same programme, and it is the same with the climate.

Every architectural composition must be constructable, for every project not so is radically nothing. Every project more difficult or complicated in construction than necessary is either bad or mediocre.

Truth is imposed on architecture, for every architectural falsity is vicious. If one of these falsehoods is excused by reason of talent and ingenuity, there no less remains the impression of inferior art.

Actual solidity is not sufficient, but must also be manifest

In your compositions provide the necessary communications, but as simply as possible and without excess. All parts must be well lighted and aerated; rainwater must pass away readily.

Composition proceeds by necessary sacfifices. A composition will at first be good, but must also be beautiful. You must then compose, keeping in view both the utility and beauty of the edifice. And as an element of beauty bu variety, you will seek for character.

Thus you will have done in architecture what depends on the architect. For it cannot be denied, that the great architect of an epoch is its social condition. The practitioner constructs, but he neither creates nor controls the aspirations of his time, but can only adapt himself best to the interests of the art. Above the works, the special programmes, there is a programme of programmes, even the civilization of each century, faith or unbelief, aristocracy or democracy, severity or relaxation of manners. There is a common bond emphasizing the identity of the art and the civilization of Greece; at Rome you recognize the increasing exaggeration of pomp and of magnitudes, the architecture of the emperors, so different from that of the republic by its compositions and programmes, far more than by its style or mouldings. Does not the S. Chapelle or Notre Dame here recall the thought of S. Louis as the personification of the pious middle ages? Versailles and Place vendome are Louis XIV himself, and later in the reaction contemporary with the school of David, its great architec is Rousseau, as Chateaubriand is the architect of the succeeding counterreaction, just as we ourselves are carried onward by a general and complex movement, that results from our ideas manners, and our existing civilization. Today our social condition is both democratic and refined, its instincts being both utilitarian and luxurious. You are too much in it to be able to escape from it, -- and besides, why should you isolate yourselves in an anachronism? Be the artists of your time -- that may always be a noble mission.

After having explained to you composition in its three great lines, I will speak to you now of proportion, or perhaps rather of proportions.

# CHAPTER IV. GENERAL PROPORTIONS.

SUMMARY. -- Definition of proportion.-- Logical and traditional proportions.-- Architect is master and responsible for proportions.--Proportion in composition; examples. -- Difficulty in the study of parts implying false proportions. Reciprocal proportions of interiors and exteriors, of courts and of halls.--Proportions of the same object according to vicinity or distance.--Examples of identical compositions diversified by proportions.

I must now speak of proportions, and it is first necessary to define them.

The word proportion is borrowed from mathematics, in which it is synonymous with equality of ratios; in an absolute sense the ratio is the quotient of the division of one number by another; in a relative sense, the proportion results from propriety of ratios, i. e., the harmony between the different parts of an entirety. In the first sense, you would say that the height of a certain entablature is one-fourth that of the column; in the second sense, that all parts of an edifice or of a certain part of an edifice are admirably proportioned to each other; likewise as you say for a certain statue, the head is assumed to be comprised eight times in the total height; or indeed that this statue is well proportioned, or on the contrary, the arms are too short or the legs too long; hence the expressions, "to be or not to be in proportion," i.e., to please or shock our instinct for harmony.

But in sculpture or painting, you have an assured base, nature as a criterion of proportions. It is not so with us; there are proportions from logical deductions imposed as such by reasoning,--always with the very wide latitude required by the arts;-- there are also very generally accepted proportions imposed by general taste, and that are however only a habit of the eyes or the mind, whose permanence is in some sort a heritage transmitted from one generation to another.

Authors that have sought to establish a dogma of these proportions, to create a sort of hieratism of architecture, have tried to give a solid basis to their theories, have desired to invoke science, have sought cabalistic combinations, mysterious properties of numbers, or again ratios such as music

finds between the numbers of vibrations forming harmonies. Purely chimerical. Others content themselves by proclaiming a legacy from antiquity with greater truth, but they receive this as an indisputable revelation, as if the artist must first refuse for himself the liberty of a man!

Abandon these chimeras or superstitions. In the study of proportions is a great part of traditions -- custom if you prefer, but also all the shades of the art, all the search for character; all the study of which you are masters and are free, on condition of knowing that in art as in all things, if liberty be most vivifying, it likewise imposes most duties. As your freedom increases, your responsibility becomes greater

Proportion is at first and primarily a quality of composition. It is unnecessary to say, that between the different parts of your composition are just proportions between what should be grand, medium or little. And do not count too much on study to ensure that proportion; study can indeed do something, but within limits imposed by the original composition. For assume that you have a court of honor, whose length corresponds to that of two lateral courts on each side; if in the lateral courts of your composition have been placed too many things, the study might demand their enlargement; but the study perhaps also demands that your court of honor should not be increased. What is to be done? Compromises, sides badly divided, and all because in the primary composition the sense of proportion was defective.

It is impossible as you see, for me to give you rules in this respect. Proportions are infinite, and an example will serve better.

Observe the magnificent plan of the Hospital des Invalids (Fig. 41), and assume this grand entirety not deserted as now, but occupied by several thousand old soldiers. Nothing is mean in this plan and nothing eccentric, yet unusual proportions are found. A vast court of honor, almost a public square, immense porticos that almost become a waiting hall before the chapel. This court must contain the invalids at reviews, processions, in all that recalls the profession of arms In these porticos the inmates of the hospital walk with crutches, pass in litters or little carriages. The chapel is a real church, because its inmates are numerous, because it is in

the age of Louis XIV. In this chapel the Dome is of great importance, as it doubles the chapel and scarcely belongs to it, being something apart and having its own reason for existence; it will be the place for the burial of great generals, while awaiting Napoleon.

Again not at the bottom of the court of honor are those grand stairways of exceptional proportions, each occupying an entire building. Because these stairs serve for infirm men, often borne on litters, for whom is always necessary a broad and gentle ascent; I have seen some take a half hour to descend one story!

And in this entire plan before reading a note, you see at a glance what is principal, secondary and merely accessory! No need of compasses or scale for that. Such is proportion in architecture.

These proportions are reasoned out and do not come from pure instinct. Assume a boarding school, where a certain number of pupils sleep at the same time, eat together, and are in classes or studies at the same time. For each of these divisions do you need four equal areas? Evidently not, for the dormitories require much more space, as you will see without the need of demonstration. Then for meals, as if the space for a pupil be no greater for eating than working, yet are required more passages for service. The study room demands a little more area than the class room; if recreation halls are required for the same persons, they will never be large enough to permit the necessary movements. And again all that may vary according to whether the pupils are young children, youths or young people. For an equal number, a room for a class in drawing will be larger than a lecture room. You may say, that all this is evident, and that to teach it is to break in an open door. How is it then, that you bring your professors compositions so frequently, that cannot be studied because of nonsensical proportions?

I could multiply examples, but it is useless. The essential thing is to make you see that a programme is reasoned out; one should not abandon himself to the pencil, but should first have fully examined the proportions latent in the programme, to make of them the proportions of composition. Something always dominates, whose dimensions must always exceed all

others, but approximative in what degree? Then something may appear as a type of medium dimensions, also something smaller than the rest. Between these types are gradations. If you have properly seen this gradation of proportions, I do not say that you will necessarily produce a good composition,-- there are too many other things yet,-- but you will not make one of those compositions, which cannot be studied, for example, where the great court is no larger than a hall, and where you acnnot enlarge one without also increasing the other, perpetuating the initial defect.

That error of proportion between courts and halls is very frequent. How many plans have been made with a court of honor continued by a hall of equal width. (I do not say length, which would not be unusual). How frequently has been reproduced at the School the plan of Garnaud's project for a conservatory, seductive by its simplicity, and which is nevertheless impossible. A court of honor is always a court in the min of its author; consider its width and ask yourselves if it be ever possible for a hall to have an equal width. I have cited the Invalids; the church is a wide hall, but including side aisles, it has nearly one third the width of the court of honor; its nave in the clear is almost exactly one fifth, not including the porticos. This width of the nave is comprised nearly three times in the width of the lateral courts. The internal diameter of the Dome of the Invalids is a little less than one third of the court of honor, or a little more than half the width of the lateral courts.

At the Luxemburg, the senate hall is large, yet two lateral courts are added to its width and to those of the communications adound it to equal the width of the court of honor (Fig. 42).

At the City Hall of Paris, the great festal hall, not including the galleries accompanying it, is a little more than one third of the average width of the court of honor, and that is a vestige of a much smaller monument. With these galleries, it slightly exceeds the half of that average width.

Here at the School observe the hemicycle with its relation to the court preceding it, the hall of Melpomene with its relation to the court of the Mulberry (Fig.43), and you will always find these widths of halls less than even the widths of

the courts hardly monumental, and this cannot be otherwise, unless the court be designedly narrow, as at the College de la Sapienza at Rome (Fig. 44L. I believe it sufficient to warn you of this without need of a demonstration.

Another general principle in proportions is the consideration of the vicinity and surroundings. Make a very simple experiment, taking a vase or statue, that you are accustomed to see in the open air in a garden; then observe a cast from it in a room; you will assert that the cast is one from a much larger object. Thus at the Museum of Trocadero, casts of all that you know in the open air will appear enlarged. Inversely, what you usually see in a room will appear much smaller if taken outside. And in an interior the same object appears much smaller in the waiting hall of the Palace of Justice than in your atelier or room, just as outside it would seem much smaller on Place du Carrousel than in an ordinary street.

The sense of proportion-- that I had reason to tell you is so delicatr-- varies according to location; or rather it is always this sense of proportion, that protests if there be a contradiction between th dimensions of an object and its position.

The open air is sometimes said to "devour" objects. This figurative expression is correct, and it is the same with distance.

If an object or a motive must be seen at distances sometimes great, sometimes small, like the obelisk on Place de la Concorde, one cannot take into consideration the natural results of perspective; but if it must always be viewed from afar, as occurs on the top of a monument, it is necessary to study not only its details, but also even its proportions. If you desire to produce the idea of a statue of the dimensions od a man, you must conceive it larger at the top of a tower than at its foot. Yet the man himself is not changed; when on the top of the tower he seems a dwarf, and likewise his statue seems a statuette.

But this consideration cannot modify necessary dimensions; like the height of the steps of stairs or of a balustrade, neither og which depends on the materials or laws of construction, like the heights of courses or combinations of stonework All this is very delicate, and I can only give you very gen-

eral advice here; I shall have done much, if I develop in you the taste for observing these phenomena, and for thus acquiring the experience, that nothing can replace.

From everything said to you must result the conviction, that proportions in construction are essentially variable. This is the art itself of composition with all its infinite combinations. Two considerations govern you here, the programme or requirements and the monumental effect.

Even this same variety according to this twofold consideration of requirements and of effect, after being established in the general composition will be found again in the elements of that composition, since to it is added a new cause of variety -- that also acts upon the composition by mediation of the elements -- that cause of the variety is the mode of construction.

Then let us study from the point of view of proportions the diversities resulting from the elements of architecture themselves.

Here are two identical compositions, and two studies of these compositions, that are two masterpieces, yet as different as possible. The superposed porticos of the Theatre of Marcellus (Fig. 45) and the superposed porticos of Palace Farnese (Fig. 46). You know them well enough without any need for me to describe them; I only call attention to their identity; an arcade on the ground story with engaged columns of the Doric order and entablature, then the second story composed of an arcade with engaged Ionic columns and entablature. Impossible to vary the description.

Yet what a difference, or rather contrast! That strikes you and everyone. But it is not sufficient for you to state this, but to see why. This contrast is not in the ornamentation, not even in the mouldings, but particularly in the proportions. It may be said that it is only in the proportions.

This principle may be stated here as an axiom.

The same motive of composition produces absolutely different expressions according to the proportion assigned to it by the will of the architect.

Or in other terms, the proportions studied freely by the architect are in the hands of that artist the means for giving to his works the art character desired by him.

Which again becomes a demonstration

Which again becomes a demonstration that the architect must be master of his proportions, for without that liberty, there is no architecture.

See how far we are from imposed formulas!

But this freedom must be exercised rationally and not by an irrational caprice. If architecture had no rules, it has laws, that cannot be violated with impunity. And it is certainly interesting to clear up as far as possible these laws of variety in proportions.

## CHAPTER V. SPECIFIC PROPORTIONS.

SUMMARY. -- Search for causes that must vary proportions. -- Application to orders takenas examples. -- Effective dimensions; superpositions; number of points of support; artistic character.--Study of proportions in interiors.--Coupled colonnades.-- Orders above a casement or a story.

Proportions in doorways and windows, derived from their effective use. -- Monumental doorways, ordinary and service door ways. -- Application to proportions of windows. -- Connec ion of these proportions with heights of stories.

Proportions of arches. -- Function of the arch. -- Great arches. -- Monumental proportions in arches. Portals of churches. -- Proportions of arched windows.

Proportions between the different elements of an edifice, particularly of arches and plat-bands. -- Exceptions. -- Infinite variety.

Conclusion that truth is the rule of proportions.

What will then be the causes that will vary proportions? The are many.

First the effective dimensions. Thus the porticos of the Madelaine(Fig. 47) and those of the oval court of Fontainebleau cannot have the same proportions.

But I take here as an example the antique orders, that are habitually regarded as almost unchangeable in proportions. If I consider a very great order, like the Temple of Mars the Avenger at Rome, I find in proportion to the diameter.

Column, diameter taken as the unit, 100%.

Space between two columns about 1 2/5 diameter, say 142%.

And since the lower diameter of the column is 5.9 ft.

Space between two columns is 8.3 ft.

Length of the lintel is 14.2 ft.

As you see, the passage is very wide and the dimensions of the architrave require stones of unusual length.

If we assume the same proportion to be applied to a much smaller order with 1.64 ft diameter, we shall have;--

Diameter 1.64 ft.

Space between columns 2.3 ft.

Length of lintel 4.0 ft.

The passage between the columns would be ridiculously narrow, while the construction permits a much greater span.

Likewise for the Parthenon (Fig. 49).

Diameter of the column 6.15 ft.

Passage between two columns 8.0 ft.

Length of architrave 14.1 ft.

If this proportion be applied to the Doric Temple of Cori (Fig. 50),--and there are smaller ones--we should have: --

Diamrter of column 2.32 ft.

Passage between two columns 3.02 ft.

An impracticable dimension, the actual width of thw passage being about 5.25 ft.

But others are more conclusive; on the same monument, the Portico of Octavia at Rome (Fig. 51), a classical example of placing a small order beside a great one, one having the proportion of about two thirds of the other, the intercolumniations are equal between axes of columns, so that the passages between columns are greater in the small than in the large order.

I could multiply these examples, taking orders more closely set than the Parthenon and more widely spaced than at Cori; I prefer to say to you, see the Madelaine and the oval court of Fontainebleau, and you will recognize this law of proportions.

In colonnades and in general in structures covered by straight arches, the greater the effective dimensions, the proportion is the more narrow; the smaller the dimensions, the arrangement is more widely spaced.

Since I speak of colonnades, I also desire you to see the differences imposed in case of superposed orders.

The proportion of a colonnade pleases you; attempt to superpose it by an identical repetition; not only will the upper order appear heavy and crushing, but the lower order seems too close and cramped. See in Fig. 53 the result of the identical superposition of the front of the Temple of Antonine and Faustina at Rome, whose proportions are perfect. Why?

In spite of yourselves and instinctively your mind observes these two repeated columns as actually forming a single and the same point of support, and cannot divert itself from the total proportion; again even with equality of effective dimensions, the column surmounted by another arouses the idea of something smaller than the column alone occupying the entire

height of the edifice, and that consequently the mind desires to see here a wider proportion, which is characteristic of the small orders.

As for the upper column, your instinct and taste imperiously demand one smaller and lighter than that below, in architecture a support should be larger in appearance than the supported part. If thinner, the upper column would also be shorter, and hence the proportion of the intercolumniation to the column would necessarily be wider in the second, than in the first order. Thus are conceived the superpositions admired by us, like the three superposed orders of the court of the Louvre(Figs. 25, 28).

But if this be true of intercolumniations, it will noe be so for entablatures, for that of the second order crowns the whole, and is the entablature for the entire monument, as well as that of the upper order. Thus it has often been treated in a more monumental manner, as on Palace Cancellaria at Rome. (Fig. 26).

In support of these theories, I can cite a very instructive example, the rear of the court of honor of the Ecole Militaire by Gabriel. (Fig. 54). Beside a central pavilion decorated by a colossal order extending through two stories are arranged porticos on the ground and second stories with superposed orders. The orders of these stories are formed of engaged coupled columns, and the intercolumniation differs little from that of the colossal order. The entirety of the two coupled columns of the two stories almost produces the illision of a reproduction of the colossal colonnade of the central pavilion.

Another cause of variety in proportions in colonnades is again the difference in number. If a facade motive, such as a colonnade or projection be composed of two, four, six, eight or ten columns, the proportion will become narrower ad the number increases. Two columns require a very wide proportion, eight or ten columns a very narrow one(Fig.55). In this demand of the eyes, there is much tradition, but also much logic; the greater the number of passages offered, the narrower may be each one; while if there be but one, it must be as wide as possible. Certainly one does not formulate to himself this reasoning, but it is often in a latent state in our

impressions, and when we seek to produce favorable impressions in the spectator, we must study these implied reasons, so as not to shock him by a misconception.

As for the shades of proportions sought by you to strengthen the character of the edifice, they are infinite and are based on personal taste. All that may be said here, is that the more you desire to arouse the idea of the monumental, the more should you retain traditional proportions in so far as compatible with your composition.

On the contrary, when fancy and caprice will be appropriate, you will free yourselves from this severity, which would become pedantry. All is a question of degree and of taste.

In interiors where colonnades are employed, the proportions should be less severe than on facades, especially if then columns are before galleries. The chapel (Fig. 56) and theatre of the Palace of Versailles are very happy examples in this respect, as well as the engaged order of the antechamber before the chapel of Versailles.

You will also see that the study of coupled columns demands proportions different from those of isolated columns. The two columns then actually form one point of support, and the intercolumniation would then be much too narrow if you give it average proportions, for then the solids and voids would become nearly equal, contradicting the idea of a portico. Thus with quite similar dimensions, the portico of the court of Mansion Soubise(Fig. 57) with coupled columns has a much wider proportion than that of the Palace of the Legion of Honor (Fig. 58) with single columns.

The proportion will again vary if you have a colonnade over a ground story; observe an elevation of the Palace on Place de la Concorde (Fig. 59), then conceal the ground story, as if the colonnade stood on the ground. You do not recognize the proportion, it seems so wide without any reason therefor. This is because it is counted with the piers of the basement arcade. -- It is that the study should be appropriate to its location.

If we pass to doors and windows, we likewise find great variations in proportions for the same reasons.

At first these openings appear matters of custom that precede all others; a door must be sufficiently wide and high,

and also--when not particularly ornamental,--its dimensions must suit easy opening and closing of its wooden leaves. Very large doorways sometimes have bronze leaves, like those of the Madeleine, and are exceptions; they are rarely opened and then by several men; but these conditions are entirely different from those governing doors in constant use.

You will find in ancient authors the indication of a proportion for doors making the height twice the width. Here again this proportion cannot be taken as a rule, and I will demonstrate this by a familiar example. In our rooms are doors with two leaves and with one leaf; the width of one is nearly twice that of the other, yet their heights are necessarily the same.

In monumental doorways are sometimes very great heights, like the doorway of the Temple of Vesta at Tivoli (Fig. 60), whose average width is 7.7 ft. and its height is 18.0 ft., the ratio of height to width then being about 2,35. The celebrated doorway of the Temple of Minerva Polias at Athens has a height almost exactly twice its width; that of the Temple of Cori (Fig. 61) is a little higher; in general these doorways are narrower than those in ordinary use; compare their proportions with those of most carriage doorways, and you will have no doubts in that respect, and yet their widths are nearly those of an ordinary carriage doorway. Whence comes the difference?

This is not from the use made of the doorway, for from this point of view the carriage doorway should be higher than the doorway through which pass only persons on foot. The reason is the desire of architects to produce a monumental impression.

What indeed is the monumental? A complete definition would be complex, but its principal character is the impression of size perceived by comparing the edifice with its own grandeur; when you wish to make prominent in a drawing this search for the monumental, you place there a human figure.

The rectangular doorway soon finds a limit to its width, especially in antique construction, which is the span of the lintel; to cover doorways 8.2 ft. wide already requires unusual dimensions of stone. But the height is independent of this control, and then it will be the height from which is demanded the monumental expression, and to obtain this the

opening of the doorway was made higher than the actual door; them it has an impost or a fixed upper part; like the doorway of the Pantheon at Rome (Fig. 62), higher and wider than the actual opening, that is very significant from this point of view. You may see an analogous example at the Madeleine, whose doorway is inspired by that of the Roman Pantheon.

Then for a far less solemn use, you still require a passage of nearly the same width, the purely orbamental height of doorways just cited will diminish; you then have doors with two leaves opening their entire height. But even in interiors continues that law of greater height reserved for a monumental impression. Thus at the Palace of Justice, the great doorway of the Court of Assizes (Fig. 63) attains very elevated proportions. Nearly the same are the doors of the royal chamber of Henry II at the Louvre, or a beautiful internal doorway in Palace Doge in Venice. These proportions are entirely exceptional in interiors, where generally the heights of stories even forbid this for doors, that are to be made wide.

And the proportion becomes greater than on monumental doors for our smaller doors with one leaf, and particularly the more modest. Here the height can scarcely vary; a minimum is always required, so that one may pass without bending the head take 6.6 ft. as the minimum. If a door be only 2.0 or 2.6 ft. wide, you see that its proportion is higher than that of the door at Tivoli cited just now.

Thus elevated proportions for monumental doorways, medium and sometimes low proportions for large ordinary doors, again very high proportions for the smallest doors, are indicated by necessity. To the study will pertain the duty of specifying each according to its destination, then arranging the proportion by its character.

Many of these considerations also apply to windows. Thus the great monumental wimdows of the court of the Louvre (Fig. 64) have a ratio of 2.43 between height and width. Those of the ground story are still higher, the ratio attaining 3 times the width. That is proper for monumental architecture, for such proportions cannot exist unless the stories are very high.

Indeed, this consideration of the height of the stories firs determines the proportions of the windows. The widths only

vary within quite restricted limits; the window with two leaves can rarely be less than 4.0 or more than 6.6 ft. wide(this is a little more than the width of thode of the Louvre), while the heights may vary from equality to threefold.

Thus you often see in the same edifice very varied proportions for the windows, notably when superposed in several stories. I cite here the superposed windows of the Louvre, of the Mint (Fig. 65), and of Place de la Concorde. Widths vary little in these examples, the differences--and they are considerable -- consisting entirely in the heights.

If I have sufficiently indicated to you what is the architectural study, I scarcely need tell you, that it is not alone on the facade, that will be studied the proportions of your windows.

The heights of the stories rule the heights of the windows; but even in that relation are possible differences according to whether your interiors are vaulted or have horizontal ceilings, are wide or narrow. Every window is made to light an interior, and must first satisfy that programme. It will be still different according to whether it is to be a house window, where one leans on it, or rather a window lighting a room intended for work or study; the window of a hospital will have its special proportions, as well as the window of a school or of an academy.

Perhaps nothinb in architecture lends itself to proportion more indefinitely varied than the window, from the mezzanine often wider than high, as on the Library of Venice, to the Farnesina, Mansion Pourtales (Fig. 66) by Duban, Rue Tronchet, or Palace Massimi, whose windows are as slender as for churches. But search carefully and you will always find a motive in these proportions -- at least in beautiful edifices -- and this reason will here again be the entire conformity of the architectural expression to the needs, material or moral, to be satisfied by the architect.

In all that I have said relating to proportions, you see apparent thr effect of construction on architecture. This is not an imitative art, nor is it an art of arbitrary conceptions or primarily of esthetics. It is before and above all the art of truth; the true has its ~~needs to satisfy, and truth~~ in construction presents the means, but truth in an artist's

hands, for there is the entire art.

We shall again find yet more varied proportions for arches. To properly conceive them, it is necessary to consider what is an arch, its reason for existence and its function.

For centuries architecture had only the straight lintel for spanning openings or porticos. Whether of wood, stone or marble, great spans were impossible; extraordinary dimensions for the material were indeed attained as at the Propyleum of Athens, where marble beams exceeded 19.7 ft; still it is a limited element, that cannot satisfy all the aspirations of architecture for grandeur.

Then somewhere, it scarcely matters where, by a single dash or gradually was invented the arch.

You see the arch daily and habit excludes admiration, but reflect; it is one of the great discoveries of human genius, one that freed art and enriched civilization, and I may add -- if the arch were produced ata single gush from a single brain -- one of the most powerful conceptions of intelligence victorious over materials.

Then the purpose of its existence is very clearly the need for creating openings wider than the length of a stone; its function is the realization of great openings.

Never forget this starting point if we desire to study logically proportions in arches.

Thus inversely to lintels, the arch may be said to have no limits of width, while its height will generally be governed by the same considerations as for rectangular openings, the height of stories or halls, the possibility of closure, etc.

So when I said for rectangular openings, that the impression of grandeur and monumental appearance is particularly in the height, I may say for arches, that you will find that impression of grandeur in their width. The niche, the smallest arch, is always slender; the great arch is broad in proportions; see the Arch at Rimini, the Arch of Titus, that of Fano (Fig. 67), and the Loggia dei Lanzi; at Paris the old arch of S. Jean at the City Hall, the ancient Arch of Nazareth (Fig. 68), now rebuilt at Museum Carnavalet, and the great entrance arches of the Carrousel next the Quay. Are these last arches higher than those of the garden of Palace Royal (Fig. 69) or of the doorway of Chapel Luxemburg? I do not

know, but of the last narriw ones and those just cited, which have grand proportions? No doubt is possible.

Nothing will make this truth more strongly felt than the study of porches or portals, like those of the principal facade of Amiens (Fig. 70). However grand it is materially, if the principal portal of Amiens were only a simple opening in the wall, it would appear small; it would again seem so were it not enclosed by a single arch. But you know the arrangement of these portals with their successive archivolts projecting beyond each other, thus formimg a large number of concentric arches. Each arch adds only one width of archivolt in height but two in width; thus without the slight difference resulting from the pointed form, the widths increase in relation to the heights in the ratio of two to one. And then note how much the proportion adds to the grandeur of appearanc by an illusion desired by the artist, your eye first perceives the widest arch, which alone determines for you the proportion of the portal.

Finally of extreme width is the bridge, the grandest expression of the arch.

May it be said that these principles have no exceptions? No, for there may always be in each composition an idea, a feeling to express in a special fashion. Thus the Gate S. Denis (Fig. 71) and the Arch de l' Etoile (Fig. 72) have elevated proportions in spite of the considerable widths of their arches, especially of the latter. But who does not see in even in that proportion, the enclosure of God or the idol, the arch made for a man and not for a crowd? An entirely moral proportion, for I conceive that if in future after a victory, our democracy has to erect arches of triumph, the proportions of their arches will no longer be that enclosing a man, but wide enough to enclose ranked regiments, and without changing its charm!

Also there are often very high proportions, those of arches lighting churches, like the great glass windows, that in some transepts have almost the height of the aisles themselves. Still an entirely moral proportion, the result of the special proportions of the monument itself.

But when the arch is only a window, the motives previously mentioned for rectangular windows still control its propor-

proportion. Therefore I shall not return to this.

The arch only lends itself to wider windows, that are no longer the single window closed by two leaves. These are then very great windows, as were those of the halls of the Baths, like those of churches, of the waiting hall in the Palace of Justice and of railway stations. Properly speaking, these are no longer windows but are great glazed arches, that naturally escape from the proportions of the window, properly so-called.

In brief, the proportions of arches vary infinitely, and this must be so, since the arch was created to permit and realize all possible varieties of dimensions and proportions of openings. The architect may here display all the flexibility of his talent, for he is the undisputed master of the material fashioned at his pleasure. Thus you see that these studies always recall the feeling of your freedom.

Is it necessary to add that one using it badly is the more responsible?

But in the same edifice you will not have merely lintels or arches, but will frequently employ both.

If you recur to the origin and the purpose of forms, you will recognize the evidence of the principle, that in the same composition the arch is the form of the larger openings, while the smaller ones are rectangular. One cannot conceive a rectangular carriage doorway in a house, whose ordinary windows are arched. It is true that the composition of arcade porticos with engaged columns and entablatures appears to contradict this principle; but looking more closely, and this motive is not disagreeable when the arrangement is merely a decoration and not an opening, but becomes so when the column is free, and thus forms an actual portico with lintels before an arcade.

Yet I recognize that beautiful monuments disobey this principle, natably the Palaces of Place de la Concorde. These are indeed motives derived from the location, from the desire of the artist to treat the ground story as a simple substructure, for emphasized contrast. I prefer again to tell you that license is permitted to great artists, and that it would be rash to question a masterpiece. That no rule is without exceptions? True, but I add that the exception does not pre-

vent the rule.

Let us leave this rule of proportions. Now that I have spoken to you of proportions in colonnades, doors and windows, arches, in the relations between these various elements, do you not see what controls them? Will this be caprice, preconceived wish, an unexplained tradition? No, it is entirely and simply, beauty by truth.

What do we then understand by truth?

Architecture employs elements of construction to satisfy material and moral needs. Without construction, no architecture.

The laws of construction are the primary laws of architecture, and all those have been destroyed thereby, who have attempted to evade them in a spirit of revolt.

Consider profoundly this verity at the base of your studies, and you will be astonished to see, that proportions arises for you from that controlling thought. When you are conscious of being true artists, you will be quite ready to felicitate yourselves as being real artists!

# CHAPTER VI. PROPORTIONS IN HALLS.

SUMMARY. -- Material and moral needs. -- Proportion and character; churches. -- Proportions necessary for certain halls. -- Halls rising from the ground. -- Variation of proportions according to effective dimensions; hygienic requirements introduction of external light. -- Proportions controlled by the nature of the construction. Proportions of halls, vaulted or with ceilings, etc.

The desired demonstration has been made, the conclusions deduced from those considerations, which were only examples for me. Have I exhausted the subject of proportions? No indeed, for it comprises all, is the study of all architecture, and this study cannot be condensed in a few lectures. Yet there remains for me to say a few words on proportions in the elements of composition.

Perhaps you do not catch this distinction, and I will explain myself.

In every composition, you will employ colonnades or windows, doorways, arches, vaults, ceilings, cornices, etc. All these have their proportions, already mentioned. But you also have halls of various kinds, vestibules, stairways, etc. All these have their proportions, which may be arbitrary, and which proceed from both reason and artistic sense. The variety is infinite but does not depend entirely on you.

In most cases, our compositions comprise several stories; thus in the same story all halls have a common height, and yet their widths,--which determine the proportion rather than thei depths, --vary infinitely. The difference is enormous between a salon or a dining room and a corridor, and there are still sensible differences between the salon and the chambers. There can be no intrinsic proportion between the different rooms; on the contrary, there results from the requirements of the plan and the height of the story an imposed proportion, that you must accept, and of which your talent will make the best arrangement possible. All that can be said, is that great heights of stories are unsuited for small rooms and inversely; the plan of one of our citizens apartments would be ridiculous with the stories of the Louvre; the arrangement must be in proportion to the edifice.

But in halls extending from the ground you are masters of proportion, at least more nearly masters.

There you have two objects, the material and the moral needs, very often in accordance. Material needs explain themselves; moral needs are imposed with less precision, but no less forcibly. Why do our churches have such elevated proportions, if not to respond to a moral need? It is certain that with the same perimeter, length and width, if you have to project here a chapel and there a refectory, you will certainly make the chapel highest, and still the refectory materially requires the greatest volume of air. But this height given to the chapel is imperatively required by the idea of divine majesty; it will be the same each time that you wish to emphasize a moral more than a material purpose. I do not dwell on these incontestable verities.

There are other motives for the study of proportions, special or general motives. In structures for utility like schools, academies, asylums and hospitals, barracks, etc., you will have to obey precise rules from the standpoint of hygiene; there the programme itself will dictate the proportions in some sort. These I call special motives, but cannot enter into details, and I pass to general motives.

We may admit that every hall extending from the ground is a great hall, and consequently we here treat of the proportions of great halls.

These halls will always have a sufficient height, for one cannot assume for them the height of a simple room. But the proportion of this height to the width cannot be constant.

Assume two halls -- in a museum if you will -- one 16.4 ft. and the other 65.6 ft. wide. If the first be 16.4 ft. high, this square proportion is not excessive. But would you make the other 65.6 ft. high? Never, for you should conform to the essential principle, that the wider the hall, the less in proportion is its height.

But other factors interfere in the study of this proportion; hygienic reasons already mentioned; if a hall is intended to receive a numerous assemblage for long sessions, you should make it sufficiently high that the volume of air suffices for respiration; then for reasons of lighting, the light should penetrate everywhere as much as possible; thus equal width

and with windows on only one side requires these windows to be higher, and conversely a higher proportion than with lighting on both sides; -- also frequently the lighting can be assured only above lower adjacent buildings; such is the case with the naves of churches, and it is again a reason for their elevation.

Finally, here again will you find the direct results of construction. Your hall vaulted in stone cannot have an undefined width, and if great width is necessary for it, you are compelled to divide it; such is the waiting hall of the Palace of Justice (Fig. 73), whose vauly is indeed of bricks, but with stone transverse arches supporting the weight; vaults of small matrrials permit greater widths, as may be seen in the halls of the Baths, at S. Sophia and at S. Peter. A ceiling or visible wooden framework admits of greater widths than vaults, consequently with lower or wider proportions, which is synonymous.

Thus observe at the same scale the transverse sections of the Cathedral of Rheims (Fig. 74) and that of the basilicas with ceilings, such as of S. Paul w-t-Walls (Fig. 75), S. Maria Maggiore, Monreale, etc. The religious idea is in both cases the same idea, even of the programme; hence identity of purpose. The compositions are nearly the same, each with nave lighted by windows above the side aisles. But the construction entirely differs, on one hand being the vault with its thrusts, its mechanical effects on the walls and itself; on the other being the ceiling where the framework exerts on the walls a purely vertical action, hence proportions are absolutely different, with the result of a different appearance and a different art.

## CHAPTER VII. COROLLARIES OF THE STUDY OF PROPORTIONS.

SUMMARY. -- Study of plans, sections and elevations is merely the same study. -- Their reciprocal dependence. --True method of study.

Study of proportions requires a delicate sense only created by the study of design. -- Identity of design and study of proportions. -- Necessity of drawing and sketches.

Criticism of errors to be condemned. -- Abuse of enormity, and true grandeur in architecture. -- Negligence in drawing.

I have shown you the admired proportions, that have made edifices celebrated and classical, and having a character common to all their variations, they are true. This truth is the beauty itself of architecture, and is their right.

That is the entire theory of proportions.

Permit me only to deduce from it some corollaries. The first is that the study of your projects in plans, sections and elevations is but one and the same study. To represent an architectural entirety requires several drawings, each the reciprocal complement of the others, and not successive phases of the study. Generally, you study your plans too much without attention to the others, then you study your facades separately, and sometimes -- but rarely -- your sections. A bad method.

In most cases indeed, the study of your plan must precede somewhat; but it soon becomes necessary for sections and facades to control, and to correct it, if necessary. Note that I mention "sections" before "facades", because it is the logical order.

I have shown you how all these are connected in the study of proportions, notably how the proportions of a facade are governed by those of the interiors. In any programme, you decide provisionally on the arrangement, which is the plan. Then you should now fix the heights of the stories, the heights of windows in relation to these stories, with the view of the best possible lighting, the outlines of the roofs, etc. Then this plan, merely a horizontal section and the section in a vertical plane, has a facade as resultant.

Not necessarily a facade, for on the contrary it is probable, that this first attempt at a facade will require numerous

corrections. Then you will require the plan and section to permit you to modify your facade, there will be mutual concessions or insurmountable resistances; finally after long consideration harmony results, and the study of the entirety is completed.

This is the reasonable study, not deceptive, and I add, the necessary study, without which there are only errors and illusions. Only thus will you become accustomed to good sense and reason, you will not produce facades like those too frequently seen in your projects, where between the windows of two successive stories are 20 or 26 ft. in height of stone and perhaps more, or indications of a mezzanine where a section does not permit the height of a story.

My second corollery is this:-- study drawing as much as possible. Drawing is the basis of the arts; without it are no artists. Do not think that I recommend drawing from the special point of view of your rendered drawings; I say more, that you never can study architecture unless you are good draftsmen. Note the failure of those who are wise and intelligent but lack this primary basis of artistic studies, and who thought to be able to study architecture with thw sole aid of science and reason. The sterility of their efforts has cruelly punished them for that lack in education.

" Proportion plays a vast part in architectural design, the sense of proportion is the chief artistic sense, and nothing develops it like the practice of drawing. With us proportions are infinite and delicate, and them are still more so in nature. How do you recognize a friend among all the men you see, even if you were to see millions of persons pass? A matter of proportions alone, for unless your friend be a monster or a cripple, his composition does not vary. But proportion is so variable and infinite, that among millions of heads are no two exactly alike. Then what is drawing? It is to perceive and then express these specific proportions, that distinguish and identify the model. The best draftsman is most sensitive to proportions.

This sensibility being once acquired is another sense enriching you, applicable to architecture as to painting and sculpture. That is why painters and sculptors could be exquisite architects, and why there has been placed at your disposal

the most extended means for studying drawing and modeling. Profit by them, I advise as an architect, who did not find at the Ecole these precious opportunities, since frequently regretted.

Also draw architecture, not after the book or the drawing. That is necessary at the beginning alone to learn to outline and to pass washes, but from nature and the completed monument I do not require you to make measured or rendered drawings, bu to make sketches.

I fear that the habit of sketching may be lost; as you become photographers, you are less draftsmen.

I have already indicated that the sketch is the most rapid means of progress in your art, for you cannot sketch anything without having carefully examined it, analyzed it in every s sense and to the bottom, nor render all that without the knowledge and possession of your subject. Not only must you seize its composition, but must fix relations without any other aid than the attentive study of proportions.

Nothing is more charming and attractive than the sketch, but the habit is not improvised. On the contrary, many must have been made before attaining certainty, and practice alone will serve you. I can only confirm here some advice on the method and selection of sketches already given in Book I relating to preparatory studies.

I again advise you to parallel studies in the atelier and before the reality, with the drawing board and sketchbook.

This method is fertile and you will be astonished by the rate of your progress.

Schools are sometimes reproached for leaving students without initiation into practice. Unjustly, for a school can teach only what can be taught within walls by the aid of books and models. But it belongs to you by initiative and will to control that instruction by the careful study of reality. Paris is rich enough in architecture to give the highest instruction. Visit other cities as you can, pencil in hand; this will teach you proportions better than I can.

I know the charm found at its school and ateliers, -- certainly I desire you to feel this, -- but that is not all, because of the custom of all days alike in passive labor; workers even devote themselves precisely and docilely to the given task and lecture, without adding the personal work of

logical intelligence; all idleness of mind and lack of will. Know how to will.

But a course in theory of architecture here is not alone a statement of general truths. It is also the occasion for truths of the present hour, addressed to all inspired by the collective state of the studies. I have the right and duty to say today to you things necessary today, that would have been useless twenty years ago., will become useless in twenty years, and I hope sooner.

Many among you have a very false conception of proportion, or thoughtless and very bad habits acquired from the fashion of a school, of careless imitation. You have the malady of grandeur, or rather of excess, believing that grandeur is in the excessive, you think to crush adjacent structures by this gross and easy artifice of dimension, and you attain the monotonous.

Thus you see daily at the School facades 328 ft. or more in length, composed of three arches, which is the fashion of the day. You would make the court of the Louvre with five bays, the City Hall would perhaps have seven or nine windows. Not all but some, and you know well that I do not exaggerate. You have heights of stories near which a story of the Louvre or of Versailles would be only a mezzanine. You have the worship of enormity.

Do you then believe, that the composition of great things adapts itself to these extravagant proportions? That would be a profound error.

Grandeur of appearance in composition is obtained by simplicity and unity. But it is also obtained by the number of elements, which prefers a long facade with more bays to a shorter one. Take the facade of Versailles next the park, which is very simple in composition and very grand in appearance; do you believe that the great projection at the middle, if composed of a few bays, would produce the same effect of grandeur due to the numerous motives-- which are further actually great, but without enormity? Conceive the old Palace d'Orsay (Fig.76) with only three arches, as certain persons among you would not fail to make it. Or again conceive the interior of Notre Dame or of S. Eustache with only three bays for their naves.

There are monuments on which this exaggeration, which is your own, has been practised to some extent. In a general way one may say, that there is always a coincidence of enormity and of decadence. Observe Grecian, Roman and mediaeval art. But I will cite examples well known to you. Thus at Paris, the Arch of the Star, in spite of all its beauty otherwise; its mass is grand when seen afar, by contrast to all the views leading to it; but it always astonishes me to recall that the arch has a span of 52.5 ft. Observe the enormous architecture of the wing of the Tuileries on Rue de Rivoli and Place du Carrousel with its enormous pilasters and its bays of 32.8 ft. or more between axes. Besides being inconvenient and uninhabitable, is it then beautiful? Is the proportion a grand thing, or is it best to seek it rather in the admirable composition of the court of the Louvre?

The colossal also had its hour in Italian art. S. Peter of Rome -- which I admire, believe this as much as may be -- or S. John Lateran presents this character. When I commenced to study architecture, I heard that the proportions of S. Peter were so harmonious, that one did not at first perceive its grandeur. Singular praise! Happily S. Peter did not entirely merit that zeal; but it is certain that to judge correctly of the grandeur of S. Peter, it is necessary to have seen it at least once, when religious festivals collect perhaps twenty thousand persons beneath its vaults.

On the contrary, as soon as one passes the doorway of S. Sophia of Constantinople -- where I have seen scarcely more than twenty persons together -- the character of grandeur seizes upon you instantly; perhaps no artist has not uttered a cry of admiration and surprise at this first glance. Yet S. Sophia is far from attaining the dimensions of S. Peter, but the effect of grandeur is not compromised by the use of the enormous, which is the enemy of the grand.

I may add that you know this well. You make the enormous by a bad feeling and in competitions. Just as if there were an art for competitions, or an architecture for the School.

This ill-omened conception of an architecture of the School, in which some of you still believe, I have opposed for twenty years; perhaps it will require a longer time still to uproot it. Since I have changed the instruction, my hatred will not

be wanting to it in this course.

I must again mention to you another criticism on the subject of proportion. You have in general acquired the habit of drawing carelessly, appearing to forget that your drawing instruments are called instruments of precision.

But particularly by the coarseness of lines you change the proportion. If a line has 1/50 inch width, how can you appreciate the proportion of a column, which at a small scale willl appear heavy or slender, according to whether the line should be taken inside or outside it? And that is not alone bad for your rendered drawings, but is especially bad since you accustom yourselves too readily to believe it accords with the proportions.

It is a sense too delicate to resist brutalities.

You see that I cannot tear myself away from this subject of proportions. I hope that this word will say much to you, for it is very vast. If in art composition is thought, proportion is feeling; a happy proportion I believe to be the most vivid satisfaction of the artist.

## CHAPTER VIII. ART AND SCIENCE OF CONSTRUCTION.

SUMMARY. -- Structures are the object of architecture; -- construction is its means. -- Construction is an art and a science. --Insufficiency in art alone and in science alone. --Artistic study of constructability; scientific methods for control of stability.

Actually the art and science of architecture.

What has heretofore been said is merely a long introduction, however vast its subject.

In this introduction has been shown the purpose; after your studies, when you have profited by the instruction freely given in this School, composition and proportion will be for each one of you what is permitted by your nature, labor, intelligence and artistic sense. I now have to speak --and this will be the major portion of the course -- of the means that architecture places at your command. Apparently a transposition, yet it is first necessary to show you your route.

What then remains to observe together?

I recalled to you the ancient very logical division of the successive operations of architecture; 1 composition, 2 proportion and 3 construction. This is the natural order imposed on the educated architect. In the studies, the knowledge of the means and result of construction must precede all the rest, for these are our alphabet and our arsenal.

Should the course on the theory of architecture make a twofold use of the course in construction? Not at all, for I have no intention to follow M. Monduit. It would be more correct to conceive the two courses as being two branches of the same instruction, no matter whether of architecture or of construction; science on one hand, art on the other.

Here I need to be clearly understoodin using the word construction in its different senses.

Architecture has structures as its purpose, construction as its means.

Art does not suffice to give the necessary certainty, science cannot create, or rather science does not create, only lends its guarantee to the creations of art.

At the School we do not construct, but all that we make is constructable; an architectural conception otherwise does not exist. What is then the procedure of the thought of the arch-

itect? To move within the domain of the constructable, there to create or select combinations, study their proportions; then after its idea is fixed, to ask science to verify the stability of its walls, vaults, floors and roofs; perhaps after that scientific consultation to return to a new artistic study of its conception, since science will have shown an imprudence or an excess of precautions.

To make this better understood, take an example. You know in the Palace of Justice the great hall, both vestibule and waiting hall, extending behind the monumental facade of Rue de Harlay (Fig. 77). Because of special combinations, it occurred to the adchitect to consturct there vaults of novel design (Fig. 78); transverse arches perpendicular to the facade, other small cross arches then forming panels, with a spherical calotte at the centre, next the walls being a surface of double curvature, which might be either a portion of a torus or of a sphere.

Who conceived this combination for producing certain effects? The artist, for no doubt is possible. Then it was necessary for him to study its stereotomy, verify its stability, calculate the varied actions of these elements on each other, and on the internal and external walls. This was the part of science.

In art, science does not greate; it is absurd and sterilized when it attempts to go beyond its part and function. Note how fruitless are the attempts at creation emanating from men however intelligent, who had only science at command. They could neither imagine nor create anything; prepared for control, they could only take something already made, vary spans or distances, solve anew the problem already solved, by merely changing the numerical data. Art alone can create, can combine the elements, i. e., compose, combine the proportions, i. e., design.

But to compose and study by the aid of our elements, always remaining within this domain of the constructable; know well that if the architect has not the necessary science, that of construction, he will likewise become sterile; compared with the incomplete architect as only a scientist, is the incomplete architect as merely an artist.

Many are unwilling to accept this truth, which is stronger

than all opposition; you must take your stand and then act resolutely; you will be architects only if you are artists and scientists. Take it or leave it.

I have just stated construction to be an art and a science, and the end of the explanation spoke of the art and science of architecture; one does not go without the other.

But the instruction is fortunately divided among several courses. I do not have to teach you science, but do have to show you the means at command, their variety and the conditions of their use, adhering to the constructable as an idea indispensable in the art. I propose to place before you the inventory of your venerable patrimony in the lectures to follow.

To begin, I shall next speak of walls. Perhaps you will ask how much can be said on that subject; you think that a wall is merely a wall; you will see, and I only fear being unable to comdense in a single lecture all, that I have to say on that subject.

# BOOK III. ELEMENTS OF ARCHITECTURE.

## I. WALLS AND ISOLATED OPENINGS.

Walls. -- Isolated walls. -- Assembled walls. -- Combined walls. -- study and thickness of walls. -- Character and decoration of walls. -- Openings in walls. -- Application to doorways, windows, tec. -- Decoration of doorways and windows.

## CHAPTER I. WALLS.

SUMMARY. -- Importance and variety of the study of walls. -- Isolated walls. -- Battering construction. -- Plinths, recesses, footings. -- Bond and solidity. -- Jointing. -- Antique jointing with stones set dry. -- Covering of the wall; cornices and their reasons for existence.

Today I must speak to you of walls. Perhaps some among you may regard the wall as the subject of a chapter on construction, and not that of an artistic lecture. This would be a profound error. Doubtless in the wall as everywhere, construction and art are intimately connected; but from the point of view of appearance and character, nothing more than the wall lends itself to a profoundly artistic study. Observe the study of the lateral walls of the Pantheon in Paris (Fig. 79) or of the Arch of the Star; those of the great reservoirs at Versailles, of the terraces at Meudon, and you will convince yourselves that painting and sculpture are not the only arts, that derive from the study of the nude their most powerful effects. Without restricting ourselves even to these nude walls, is there not again a study of the wall on the stories of the Louvre, on the ground story of our School of Fine Arts, and of Mansion Pourtales in Rue Tronchet? And if we leave Paris, we then find the justly admired walls of Grecian and Etruscan antiquity, the great supporting walls of the Capitol of the Tabularium (Fig. 80); the great and imposing wall of the theatre of Orange and the elegant walls of Pompeii; in the middle ages the walls of Carcassonne (Fig. 81), of Guerande, of Moret, etc.; later the grand terraces of Blois and of Amboise. So many walls were conceived and studied by artists with the will to produce a work of art.

On the other hand, the wall is the primary element in every work of architecture, and is also the simplest. It is then logical to speak of it first of all. Let us endeavor to know

it well.

Functions of walls are very diverse; in a general way, they may first be divided into two groupe.

Isolated walls and connected walls.

The isolated wall -- such as the wall of an enclosure -- must support itself by its own structure, its intrinsic stability. The connected wall -- the most general case -- borrows a part of its stability from its connection with other walls that reciprocally support each other.

Observe in our cities a house of five or six stories; its facades and partitions are formed of walls with a thickness averaging only a fortieth or fiftieth of their height. Could such an isolated wall be constructed in space? Never, for it would not even resist the pressure of the wind. The connection with other walls alone supports it, which is the condition necessary to its stability, very great if the connections are good.

Thus you see that your architecture proceeds by combinations; its stability is due to ingenious artifices, thanks to which it has been able to economize material, money and space. I say "our architecture" and not architecture, because it has not always been so. In monuments of high antiquity, otherwise very remarkable, walls have been very timidly built with thicknesses necessary to ensure their stability by their own mass, without recourse to their connections. Such is Egyptian architecture; and then you see immediately how such a mode of construction contributes more than all else to give to architecture its proper character; for example, compare the plans of the propyleum of Karnek (Fig. 82) and of that at Athens (Fig. 83); nothing can be more opposed, with timtd construction on one side, wise construction on the other.

The connected wall will have by its purpose, dimensions and a composition essentially relative to an entirety; while the isolated wall is an entirety by itself and a construction -- an edifice -- for itself alone.

Then the isolated wall is to be studied first, the principles of its construction being applicable to the connected wall; the thickness alone varies according to the laws of stati

### Isolated Walls.

As purely logical, each construction in masonry should be pyramidal. Assume a very high wall; its top course supports no load; the bottom course supports the entire weight of the wall and transmits it to the ground. From the bottom course and especially the ground, to resist that considerable pressure, it must be distributed over an area sufficiently great.

The theory of the resistance of materials leads to a section (Fig. 84) determined by two concave curved surfaces more or less distant according to the elements of the calculation (density, resistance, etc.). But such a wall would be inconvenient, irregular in appearance and difficult to construct, and in practice the same result would be obtained by recessions or offsets (Fig. 85), which permit the retaining of vertical or slightly inclined planes. Note also that this wall is more economical by its recessions and is also more stable; then if you make it of equal thickness at top and bottom, that would be a useless mass only serving to load the foundation uselessly.

This places before you at the beginning of these studies two principles.

1. Architecture should be enlightened by science, but apply the conclusions with intelligence and in a practical sense.

2. The pyramidal effect formed by monumental architecture in footings, batter, bases, plinths, etc., is a rational law of architecture, and satisfies both the eye and safety, the need of safety that we expect from every structure.

This wall will not be a monolith, but it will be of large or small materials or of mixed construction, To each of these modes of construction corresponds a specific architecture. First take a monumental wall of cut stone.

For greater simplicity, assume that you have at hand stones like those always supplied by the quarries of east or southeast France; of square section; length twice the width (actually 1×1×2 ft., or 1.08 × 1.08 × 2.17 ft.) and first examine the case of a wall with a thickness of one of these stones.

If you divide the wall in vertical slices of 2,17 ft. each as at A (Fig. 86), it will have no stability and the least push will overthrow one of these slices. If you break the joints as

B (Fig. 87), you will secure all the stability possible, having formed an entirety.

Your wall should then be divided in horizontal courses with broken vertical joints.

This principle is rigorous, whatever the mode of construction of the wall, or its thickness, etc., and the broken joints on the facade must also exist in the interior, when a single stone does not make the entire thickness.

Then let us consider a wall of double thickness. On a first course $A^h$, $A^v$ (Fig. 88), you can place a second $B^h$, $B^v$, where the stone s will be in inverse order, the joints being broken both ways, and the construction is excellent.

These jointings (a term derived from stonecutting) are as ancient as architecture. For the first I cite the wall of the Erechtheum at Athens or the magnificent tomb of Cecilia Metella at Rome (Fig. 89); for the second the wall of the Tabularium of Rome. (Fig. 80).

But the stones do not usually have this general regularity, producing regular jointing both ways. Generally stone is employed according to the dimensions of the blocks, always in horizontal courses. Broken joints are always the rule. The jointing is very frequently regular horizontally, i.e., with courses of uniform height, the vertical joints not being regular. It is also evident, that entirely regular jointing forms another beauty.

In antiquity are found examples of walls of very beautiful construction, whose joints are not always vertical, for example at Mantinea, (Fig. 90). That is practically without inconveniences, if the angles do not become too acute, for generally every acute angle is dangerous, being too easily broken.

Regular jointing sometimes has courses alternately high and low, thus permitting the use of different layers of the same stone. There are beautiful examples of this combination. Finally, I should cite here, rather from the historical point of view, the walls termed Cyclopean or Pelasgian, composed of irregular blocks cut polygonal and inserted between each other, as in the walls of Argos or Tyrins. In these primitive structures with the inconvenience of not placing the stones on their beds in the direction of their natural stratification, you find again the endeavor to break joints.

Rubble walls and brick walls are governed by the same laws, the proportions of the materials alone differing. Walls of rough rubble, boulders and grit are rather analogous to Cyclopean walls; also especially for the latter the combination by mortar causes their solidity by making true artificial monoliths.

Here in regard to walls, I must speak of a beauty unknown to you by examples,—except those born near Nimes, Orange or Arles, of masonry set dry. In all antique architecture stones are set without mortar, stone on stone. You understand well that this can only be done with perfect execution, and the theoretical plane of geometry here becomes a reality, for otherwise contact occurs at certain points, very heavily loaded, and the stones would break under pressure. Need I describe what beauty results from this perfection?

Do not think the word perfection exaggerated; I was measuring the Temple of Mars the Avenger at Rome, and I had very carefully measured the stones of the substructure. In laying these off on paper, their dimensions were constant, except being sometimes doubled. Looking again with minute care, I then found the joints previously invisible in spite of all my care.

If so treated, a wall of simple masonry assumes an art value, not suspected before having seen it; the beauty of execution ensures the beauty of the monument.

For a superior beauty results from the construction itself, i.e., the architecture and not required from any later decoration. Such is the case with Tuscan or Etruscan walls. You have seen engravings or photographs of the grand walls of Palace Pitti, (Fig. 91), Palace Strozzi, Palace of the Signory at Florence(Fig. 92) and Abbey of Belem in Portugal. Those bosses with such a powerful effect, rustications, shadows and lights, are better than decoration, being the construction itself. On the rough stone of any sort is determined the vertical plane face, or the edges of the inscribed prism, this plane being marked by pitching off around the face, leaving the front of the stone as it was. The joints are not drafted, the projections are not bosses, but the stone itself with all its diversity. I have measured on Palace Pitti projections of 2.3 ft. from the plane of the wall.

Let us return to more ordinary conditions of construction. Take a portion of the constructed wall; it has its foundations extending to good dround with the necessary footings; then a plinth or thicker lower part formed of larger and stronger stones; finally the wall is completed to its height. (Fig. 93). It has an enemy to be feared, the rain that causes the destructive effects of frost. If the stone be soft, it is absorbent and the joints will be full of water, so that the wall must be protected. Hence the cornices.

## Cornices.

The cornice is the crown and shelter of a wall.

Walls and especially simple enclosing walls are protected, either by tiles or sheet metal (zinc). But instruction must be sought in monumental architecture; I prefer the cornice of stone, advising you to follow carefully the reasoning that brought it to its richest form.

To protect a wall, it was first crowned by a course of hard stone in as long pieces as possible, so as to diminish the number of joints, crowned by a wash to throw off water. This is the cornice crowning the enclosing wall of Prison Mazas.*

But if water cannot penetrate the top of the wall, it runs down the wall and thus injures it. Hence the idea of a projecting slab, perhaps a course of hard stone projecting beyond the face of the wall (Fig. 95). But the water wets the stone after running down the wash and again follows the surface of the wall. It is then necessary for it to fall off. Therefore the under surfaces are under cut so as to compel the water to fall off before wetting them. The slab has become a coping with drips (Fig. 96). Then to give greater projection without risking fracture of the coping, it is strengthened by mouldings, and finally noting that its vertical face is soiled by the water, it is crowned by a drip moulding to reject the water Trace this result and you have the Greek cornice, like the example from the Propyleum of Athens (Fig. 97).

Thus the cornice first consisted of a coping with drips; of lower and upper mouldings less important than the facia, always dominating in height and projection. In the infinite variety of cornices, you always find this principle as a rule.

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*Note. All projections in prisons are forbidden, hence the coping has no projections.

We shall see its application later; I wxplain the theory now.

With different forms the same principles and care were motives of the design of the mediaeval cornices. Architects increased the upper slope to remove water more rapidly; from this resulted different mouldings and an appearamce as in the examples. (Fig. 98). But you always see the idea of protecting the wall from rain. Yet mediaeval architects, working generally in more Southern climates and with stone less suited for great projections, have arranged their cornices accordingly with smaller projections and with surfaces exposed to rain. Architecture must find varied solutions when the problems differ.

I do not assume to indicate that the conception of the antique cornice would not be applicable to our climates, for this would be a calumny in view of so many beautiful wxamples. But it is important for the resistance of the stones to be perfect, or that the top of the cornice be covered with lead, according to an excellent custom. The cornice then plays the part of a crown supporting this metallic protection, permitting the rain to fall far from the wall, thus ensuring a more effective protection.

In general it is prudent to cover with metal projecting cornices, when the wash is not much inclined. Rain is the enemy to be feared at all architectural projections.

## CHAPTER II. WALLS; CONTINUED.

### Connected and Combined Walls.

SUMMARY. -- Connected walls. -- Various cases of intersection of walls. -- Danger of disjointing. -- Free treatment, simplicity. -- Combined walls of different materials. -- Equal settlement. -- Horizontal and vertical combinations. -- System of construction of Roman walls. -- Vertical lines of quoins.

Leaving the isolated wall, we shall study the connected wall It will be external or internal, and for the present, doorways and windows will be omitted.

Any portion of a wall comprised between two intersections is quite analogous to a part of an isolated wall, for its thickness may differ, but not its mode of construction. Also generally this wall will have but one face, if external, and none if internal.

At intersections of different walls appear special problems in their connections. The conditions of these intersections may be reduced to three general kinds.

1. Connection of two walls at their ends, i.e., at an angle of the building (Fig. 99).

2. Connection of the end of one wall with another continuous wall; such is the case of a partition wall joining a facade wall. (Fig. 100).

3. Connection of two continuous walls, like two intersecting internal walls (Fig. 101); all surfaces are then internal, or if at the angle of a court, then will there be two facade faces.

The other very varied junctions of walls are merely applications of these three general modes. It is further unnecessary to state, that those walls ban be equal or unequal in thic ness or of different materials, visible or not, according to their purposes.

Now in every junction of walls is to be feared a separation. The essential condition of the stability of a masonry structure is its solidity. And here again it is ensured by bonding. The connected walls must have as many stones in common as possible with bonding of the joints.

Thus in the first case may be obtained a certain bonding by a very simple jointing (Fig. 102); yet though this jointing

is quite sufficient in many cases, it does not entirely prevent diagonal disjointing; under the effect of internal pressure, the angle may open as in Fig. 103. This is because no stone here actually belongs to both walls, stones A being a part of wall A and stones B belonging to wall B.

A better jointing will occur by arranging stones really common to both walls and alternately like a, a and b, b (Fig.194). This arrangement is more costly because it assumes re-entrant angles in the stones and waste, but it is perfect as construction. And it is always necessary to pay great care to the study of the stability of the angle of a building. The common name of cornerstone of a structure indicates what should be immovable, and is found in all languages and all ages.

Then remember well this advice, whose principal application you will find in angle quoins.

When the junction occurs, not at an angle of the building, but in one of the two cases mentioned later, the theory will be the same. The best jointing will always be that employing stones common to the two walls, i. e., in form of a T in one case and of a cross )a, a and b, b) in the other (Fig. 105).

After showing what is good, it is perhaps useful to see what is not so -- although frequently used. Assume the intersections of the walls A or B as in Fig. 106; you can already see how good construction would be difficult in these conditions; it is truly necessary to torture the materials to obtain bonding, and yet these are insufficient.

When for arrangement or effect, a wall cannot be continued in a straight line, this is termed an offset. An offset should never be abused, is practical when frank as in plan C, for you then really have two distinct walls with an intermediate space in which bonding is possible, but you must see that it is not the same for examples A and B.

This shows that a construction should always be frank and not undecided. This is a constant rule, and you will often hear that a thing is frank or not frank, an approval in one case, criticism in the other.

In all the preceding, it is well understood, that I give only theoretical indications, really susceptible of numerous varistions. But theoretical rules determine the architectural traditions, that you will have to study, and it is this, that it is important for you to know first.

### Compound Walls.

To conduct these primary studies from the beginning, it is now necessary for you to know compound walls, i.e., those composed of different materials.

The wall entirely of cut stone is indeed a luxurious constru tion, and even in monuments are fre-quently employed stone with other materials, particularly rubble and bricks.

Stability should always be sought in these systems; it is always by means of bonding and intersection of the materials, that this is obtained. But there are other considerations, and first is the judicious distribution of the materials, with equal settlement, whether this relates to isolated or connected walls.

In a wall composed of cut stone and small materials, stone gives the reality and the appearance of strength and of base; small materials are proper for filling. Thus it will be logical to first make of the stone the plinth, that forms the bas of the wall, and the cornice that protects it.

Between the two horizontal lines of base and cornice, if there be a mixture of materials, we find two general methods, the horizontal and the vertical combinations.

If the wall be uniformly loaded, nothing is more logical than the horizontal combination, i.e., alternation of equal or unequal courses of stone and of small materials, like the walls of the Hospital of Hotel Dieu at Paris (Fig. 107), or again an alternation of rubble and bricks as at Museum Cluny.

These combinations indeed have the advantage of ensuring an equal settlement. Settlement is a slight loss in the height of a work in masonry under the pressure of its own weight and the loads supported by it, produced in the mortar of the horizontal beds; neither the stones nor the bricks yield, but the bed joints. Then the more numerous the bed joints, the greater the settlement, and with equal heights a wall composed of ten courses of cut stone will settle one-tenth as muc as a wall of a hundred courses of bricks. ( I here assume no settlement due to the soil).

The consideration of settlement may afford a motive for very judicious departures from the principle of bonding. We find a very instructive example at the Coliseum. The facade

wall is there of cut stone set dry and consequently without possible settlement; behind it is an oval wall also of cut stone; vaults connect these two walls, forming an annular structure, perfectly homogeneous and possessing a stability in itself. Then between these porticos and the arena beneath the seats are the concentric walls of the sections; these are in bricks and concrete, connected by rampant tunnel vaults. This is also another perfectly homogeneous structure, having also its own stability. But one can and must settle, while the other cannot do so. Between the stone wall limiting the porticos and the concentric walls of the sections is no connection, not a bond stone (Fig. 108); these walls are in contact, but are completely independent of each other; an instructive example of judicious considerations, that should decide the architect in each case.

Construction on horizontal bands may be seen in very beautiful monuments, Particularly in Tuscan architecture of the 14th century, where the stone or colored marble clearly accents this idea. It has always the inconvenience of taking from the wall the appearance of unity, more readily imparted to it by vertical lines.

Division by horizontal bands is also found in Roman architecture, even in walls to be plastered or covered with marble. This is a method of construction. To build walls of very great thickness, the Romans placed a horizontal layer of several rows of bricks (Fig. 109), then for a height of about 3.3 ft., they constructed the two faces of the wall either of bricks or rubble, generally triangular; the middle space between these faces was then filled by a concrete of small stones and mortar; finally a new course of bricks closed this sort of box, its covering being the bottom of the succeeding box, and thus continued. This practice was only suited for very thick walls. As for the external appearance of these walls it is exactly that of a brick wall, the faces being entirely composed of bricks.

The combinations of walls very frequently consist of vertical divisions, these either resulting from the construction or merely intended for decoration.

When in a wall (always assumed solid) there exist vertical divisions of cut stone with small materials, the stone is nat-

urally indicated for the parts most heavily loaded; junctions of walls, divisions beneath girders, etc. Superposed courses of stone thus forming a vertical support are termed intermediate quoins (chaines), distinguished especially from angle quoins.

In a wall so constructed, the cut stone will occupy the least surface, and between the intermediate quoins is found the filling. Fig. 110 exhibits the theoretical elements of this combination, and calls for the following remarks.

1. Quoins consist of regular masonry; it is best that the number of courses be odd, and that the vertical quoins begin and end with long blocks.

2. Quoins are cut with the stones alternately projecting, so as to assure the bonding or junction with the small materials of the filling. The excess in length of the long stones (a, a) is termed toothing.

3. The projection of the toothing is not arbitrary, but depends on the nature of the filling. If the filling is itself cut in stone, the projection of the toothing will be greater in order to form a good bonding, this study will then be that of the jointing of the wall, simply accented at the quoins by the relief of those stones; if the filling be in rubble or bricks, this projection will be half the average length of a rubble stone or of a brick (about 5.9 to 7.9 ins. for rubble, 4.3 to 4.7 ins. for bricks).

4. If the filling be of bricks, the height of the courses of bricks not being arbitrary, the heights of the courses of stone must agree with an exact number of courses of bricks.

Thus according to the nature of the filling, the forms of the vertical quoins will vary as in the three examples(Figs. 111, 112, 113).

For internal walls, if they must remain visible, as in certain vestibules or porticos, naves of churches, etc., the rules will be the same. If they must be covered by plaster or any facing, the same regularity is not necessary, provided that the requirements of the construction are observed.

# CHAPTER III. WALLS; CONTINUED.

## Study and Thickness of Walls.

SUMMARY. -- Thickness of walls determined by requirements of construction and of climate; obtaining an effect or a desired appearance; results of an architectural decoration. -- The effects of construction upon walls. -- Case of equilibrium. -- External and internal walls. -- Walls with fire-places and flues. -- Stability of isolated walls. -- Buttresses. -- Appearance of walls. -- Monumental power of g great thickness. -- Thickness resulting from successive offsets. -- Overhangs.

In the same edifice the thickness of the walls generally vary. The determination of the thicknesses results from very different elements, that can be collected in four general causes.

1. Requirements of construction.
2. Requirements of the climate.
3. Obtaining an effect or a desired appearance.
4. The results of an architectural decoration.

Construction. -- Walls must resist the stresses tending to crush or overturn them; the former are most frequently vertical and act by pressure, the latter are lateral, acting by thrusts or by flexure. Lateral stresses may be neutralized, if a wall receives from both sides thrusts from identical vaults, when equilibrium occurs, and the wall supports only vertical stresses (Fig. 114).

Scientific study of construction will later enable you to find these stresses; calculations are very simple in most cases, but are very becessary, for nothing is more dangerous than to trust to routine or to determine thicknesses by guess; as one is very bold or timid, he errs by lack or excess of thickness, producing danger in the first case and useless expense in the second. Perhaps in regard to the thickness of walls the architect has the greatest duty of economy, the obligation of an honest man and practician.

But at present, without entering into details of the calculation of stresses acting on walls, it will suffice to deduce general principles of proportions.

Generally, an internal wall is in practical equilibrium; an external wall of an edifice is never in absolute equilibrium,

having lateral stresses on both faces, that cannot be the same, and unsymmetrical vertical stresses. Then in principle, the external walls should be more resistant and thicker for the same materials. Another reason is that they protect the edifice from cold, heat, etc. Yet an internal wall may require an equal or sometimes greater thickness, if it must resist the thrusts of vaults not abutted.

In the interior must be distinguished between walls supporting the construction, -- floors, foofs, tec., -- and those merely simple division walls, that may be light partitions. Yet it is also necessary to consider walls, that without supporting the construction, must contain chimney flues or hot air ducts. (Fig. 115). As good practice, their thickness should not be less than 20 ins.; light partitions are generally 3.2 ins

From the point of view of pure construction, it certainly would be better if chimney flues were not in the walls. The walls are the primary element of the stability of our buildings, and it is evident that a flue that intersects them from base to top is a permanent danger, whatever care be taken. A chimney flue endangers the wall far more than the much larger openings of doors and windows, above which the wall recovers its solidity. The old method of chimney flues always against th wall was then preferable. But we have to count too much on the economy of the site to permit ourselves that luxury, especiall in cities. In any case, I must point out all dangers from chimney flues in the external walls of buildings; they are often used, yet the flue runs from top to bottom of walls that shoul be homogeneous, without counting that those flues are exposed to external cooling in conditions injurious to their action.

Brick walls have thicknesses fixed by the number of bricks in the cross section, from 4.33 ins. for a single row; then occur 8.66, 13.00, 17.32 ins., etc. But because of the space occupied by the points, it is necessary to count 9.45, 14.17, 19.0 ins. between the two brick faces (according to the dimensions of bricks in use at Paris and a great part of France, except variations due to local custom in manufacture).

As for isolated walls, perfect construction of a long wall is difficult, and it easily occurs that the walls are curved, their surfaces being warped instead of remaining plane. To avoid excessive thickness throughout, it is often necessary to combine these walls with buttresses, making them actual con-

rected walls (Fig. 117; A, A are buttresses). These buttresses are really projecting intermediate quoins; we shall later see what architectural forms are given them.

Terrace or retaining walls and those of basins or reservoirs are exposed on one side to great lateral pressures. They require great thickness at the base, and are always built with large offsets inside or outside, ordinarily with strong batter (Fig. 118); A is a wall with internal batter and external offsets; B is a wall with external batter and internal offsets). These may both be on each face; finally, these retaining walls frequently have buttresses. Their pyramidal appearance them gives security; we shall later see how recesses may usefully be made in them.

Climate. -- At first sight, it would not seem that climate should influence the thickness of walls. Yet a function of architecture is to protect man from the dangerous or merely inconvenient effects of the enclosing atmosphere and external phenomena. In tropical countries, one must be protected from heat, near the poles from cold; whether from heat or cold the means are always the same, shelter by a structure thick enough to suppress heating or cooling surfaces. Temperate countries alome need less defence against external temperature, and thus tropical and polar structures are much alike.

But in fact this cannot be. The exterior not only affords us heat or cold, but also light, abundant and even blinding in the South, rare and dim in high latitudes. Then in the North -- or in the extreme South -- much larger windows are required, most important cooling surfaces, which alone suffice to break the equilibrium. Protection from cold is also by clothing, from heat by shelter alone. Always in hot countries the enemy -- the torrid sun -- has been opposed by thick walls w with few openings, with an arrangement placing in shady courts the ventilation and lighting of the house. Oriental plans always show this case, and I will cite as examples the Arab struc ures near Palermo, the Ziza (Fig. 119) and the Cuba (Fig. 120) or a house at Cairo (Fig. 121). The walls in these edifices are often hastily built of defective materials, crude bricks and mud mortar, but thickness is always sought, and in these coubtries is the primary condition of the habitation.

Appearance of Walls. -- Beyond the requirements of construction and never less, you can be guided in determining the thickness of walls by considerations of appearance or character.

A thick wall with deep openings for doorways and windows, arouses theidea of richness and monumental effect. Everyone is struck by the beauty of thick walls characterizing powerful architecture, affording play of shadow and kight, with monumental perspectives. These are powerful means of effect, very legitimate when the programme is adapted to the monumental appearance, but which should not be lavished unnecessarily or exaggerated when the programme demands modesty; the tact and feeling of the artist must settle these delicate questions and ensure the harmony, that should exist between the effects of the thickness and the decoration of walls.

Results of an Architectural Decoration. -- In monumental architecture a wall is often sensibly thicker than is demanded by either construction, decoration or appearance, like certain walls of the ground story at Versailles, the Louvre, etc. The fact can be proved to exist in the ground story or at the base of an edifice; look above for its explanation.

I have called your attention to the character of stability that shouls exist and appear in every edifice. The projection of plinth or offsets existing on an upper story must be carried by a lower story, as otherwise overhangs occur, which should always be avoided.

For example, assume them on the second story projections as in Fig. 122. The wall of the ground story will be vertical inside, and with reference to that of the second story, will have an extra thickness determined by the entire projection of the section of the offsets A, A, a projection exaggerated here but often very pronounced.

If above a plane ground story you place a second story with engaged columns, the extra thickness will comprise the actual projection of these engaged columns, adding the section of their bases, offsets or plinths; such is the case of the Ecole des Beaux Arts at Paris (Fig. 123), with its profile in Fig. 127 and plan in Fig. 128, the Palace of Justice on the pavilion of the court of honor and on the facade on Rue Sainte-Chapelle (Fig. 124), at Versailles on the facade of the theatre of the Palace on Rue des Reservoirs (Fig. 125), and a multitude of other monuments. These combinations may vary greatly and not necessarily assume the use of the orders; thus at the Palace of Justice on Quai de l' Horloge, the facade on which above an entirely plane ground story rises a second

story with buttress projections (Fig. 126).

From the perceding figures, you will easily take into account these laws of construction, when you arrange on the plan the superposition of two stories indicated by lines of recession and by hatching.

From this demonstration must be retained an essential rule, too frequently forgotten by beginners, which is that a plan can be definitely fixed only after the study of the section and the facade.

Then this other principle, that if the effects of projections ban be obtained for an upper story only by overhangs, it is much better to renounce them; an overhang is always bad construction, and its appearance is nonsensical. Assume the profile previously shown, placed as in Fig. 129, and you will find it shocking; if presented in section, you will have an incomplete idea, but it must be represented as seen at the angle of the edifice, where is better judged the profiles and outlines; then the projections appear in the proportion of the diagonal to the side of the square, and for the section C - C, you will have an angle D - D of the facade. This will suffice to protect you from overhangs, which are a vice, and should not be confounded with corbellings (Fig. 130), a mode frankly desirable and hence susceptible of perfectly legitimate study.

## CHAPTER IV. WALLS; CONTINUED.

### Character and Decoration of Walls.

SUMMARY. -- Character of walls chiefly consists in their construction. -- Character of materials. -- Plinths and substructures. -- Sunk joints and bosses. -- Angle and intermediate quoins. -- Belts, bands and cornices.

I have explained to you the theory of walls in their various combinations. But when this wall must play an important and artistic part in your composition, what will be its character? This will primarily be that impressed on it by the mode of construction selected. According to the needs of construction and also to the impression to be produced, your wall will be of cut stone, of mixed materials, or again be covered by a facing of marble, stucco or painting.

The antique wall of stone or marble is the grand architecture of the nude; the wall at Pompeii with its stucco and paintings is refined elegance. The Tuscan wall was previously mentioned and is the scorn of artifices; the wall of our Pantheon is solemnity. I might go farther but only desire to show you the variety of impressions the artist can produce with this element, of the wall.

Leaving these monumental conceptions, you will see the wall of small or mixed materials employed by preference for utilitarian programmes; bricks, especially if combined with stone, bringing gayety of color to our facades, as on the buildings of the National Library, Rue Vivienne (Fig. 131); severity of appearance is also due to the mode of construction, like the grand walls of old Prison Mazas, so identical with the character of the programme, and that would certainly have been less expressive, had their construction been different.

As for the decoration of walls, it is infinite and often borrows the means from the elements to be studied later, especially the orders. I cannot now speak of the decoration based on the conception of the wall itself. Yet the word decoration is proper here, for in all higher art, it is the sincere expression of the construction itself.

The surface of the wall will be plane or designed with projections. In the first case, the beauty of the masonry will

especially decorate the wall, as well as the contrast value of great nude spaces between the projecting forms of adjacent parts. As for the projections on the wall itself, we shall here examine elements peculiar to the wall.

First the Plinths. -- In the construction of the wall logically occurs a greater thickness at the foundation than above. Stabil ty requires it, especially if the construction of the foundation is less resistant, as with rubble or grit-stone beneath a facade of cut stone. Hence the element of the base of the wall, a transition between these two thicknesses. This is the function of the plinth.

The plinth can only be a course thicker than the wall, and this course will be of large blocks of hard stone with the smallest number of vertical joints. On certain antique monuments are several courses of plinths, generally three, receding behind each other. Such are the steps, not to be confounded with actual steps, extending beneath the columns of the Parthenon. You may see such plinths with less projection at the Library S. Genevieve in Paris.

Most frequently the upper part of the plinth terminates in some mouldings; it sometimes becomes a true substructure with rich profiles, such as you see on Palace Giraud (Fig. 132) and the Cancellaria at Rome, by which is inspired the less rich substructure of the Palace of our School of Fine Arts. To be cited are the plinths of several churches of Venice, notably Church S Zacharia (Fig. 133), those of the palaces of Florence, often in the form of a bench (Fig. 134), those of Bologna, of the Arch of the Star, etc. The character is always the footing or base of the edifice on the ground, a strong base, and the design gradually attains refinement as it rises from the ground. Always at the bottom is a plain course to receive shocks, the mouldings only beginning above it, for when you see on a beautiful monument, like the Louvre, delicate mouldings almost at the ground, this is always because the monument has been partly buried.

In this study we then find recesses and bosses. These two terms express almost the same thing, but not quite so.

A sunk joint is a joint sunk after the execution of the facade, horizontal or vertical, but must always express the jointing itself.

It is impossible in principle unless the face has sufficient projection for the wall to still retain at the bottom of the sunk joint the thickness and projection required by the design of the edifice. For the bottom of the joint becomes the face of the construction.

The sunk joint may be of rectangular section, as on the ground story of the School of Fine Arts, or rounded as at the Mint. In the last example only the horizontal joints are accented, in this respect only depending on the effect to be produced. As for the arrangement of the sunk joints, this will follow the jointing, whether regular or not. The sunk joint is indeed only to accent and show the jointing.

The boss is a stone projecting from the face like quoins, to be treated later. The word boss is used rather than sunk joint to express the idea of projection of the stone, rather than that of sinking the joint, and particularly when any decoration emphasizes this idea of projection.

In principle, the boss is a stone prepared and set with this projection already made; its face determined by the cutting at the joints.

I have spoken of the very energetic bosses of Tuscan walls, a tradition of Etruscan antiquity. An analogous character is found in the bosses of the entrance pavilion to the oval court of Fontainebleau called"Baptistery of Louis XII" (Fig. 135); the stone employed is hard gritstone, allowing nothing but rusticated and rude cutting, which is the appearance of these bosses. I will also indicate an inspiration in the bosses of the Ministry of Agriculture, Rue de Varenne.

But most commonly, bosses are coursed. Frequently simple projecting courses, sometimes with rounded edges, as at the Luxemburg, or the boss is entirely cylindrical, as may be seen on various parts of the Louvre, Rue de Rivoli, or next the Quay, or indeed as nail heads. On the contrary, the base is often richly moulded, like those on the building of the gallery of Apollo next the garden of the Infanta at the Louvre (Fig. 136), where is also a contrast of the stones with the projecting marble bands.

Finally, there are numerous examples of decorated bosses, thus vermiculated bosses, very common and a singular imitation of the destructive effects of saltpetre and frost; most

celebrated of all are those of the Louvre along the Seine (Fig. 137), or those of Philibert de l'Orme at the Tuileries, of which you have a specimen in the court of our School next the Quay (Fig. 138); both have an exquisite delicacy and charming invention.

In the architecture of fountains, stalactites are frequently seen imitated. Such are the bosses of the fountain of the Luxemburg.

But it must be said that bosses decorated by sculptures, casings or inlays, are charming only by exception. Bosses arouse a different idea; not that richness is excluded, for on the contrary their appearance is rich; but primarily they express strength and energy. Bosses are employed to strengthen and show the jointing, to accent construction in stone; to the logical and regular jointing of the stone correspond the regular bosses, while alternation is only a caprice.

You will further see on the same edifice a variety of bosses. On Palace Strozzi, on Palace Cancellaria (Fig. 26), the bosses are refined and assume the lightness of the upper stories, and in a certain measure, it is the same at the Luxemburg.

From the boss to the quoins is an entirely natural transition; the quoins being a series of stones with bosses, whose purpose is to mark the junction of two walls or the piers more strongly accented, where the wall is more heavily loaded.

There are angle and intermediate quoins.

Angle quoins mark the junction of two facade walls, and the lengths of the shortest stones should at least equal the thickness of the wall -- a little more if the angle stones have reentrant angles inside (Fig. 139).

The toothing necessary for the construction must always appear in the decoration of the bosses; such is always the composition of the magnificent motives of angle quoins of Italian architecture, the finest example of which is presented by Palace Farnese (Fig. 140). You find again this motive at the Louvre in the facades on the side next Rue de Rivoli.

Then vertical projecting quoins, whose sides are limited by two vertical lines without visible toothing, are in contradiction to the construction. Yet there are fine examples of these, certainly of an inferior art. It is the same with quoins

wider than the possible width of a wall, for example the quoins at least 9.8 ft wide above the piers of the great gates of the Carrousel.

Returning to quoins like those of Palace Farnese, I shall call your attention to the requirements; retaining the same vertical line from top to bottom for the line limiting the lengths of the shortest stones, consequently a difference between their lengths in different stories when the facade has offsets; the wall itself is thus translated into the elevation; such is the design of Palace Pandolfini at Florence (Fig 141), whose architect was Raphael himself; -- the toothing frankly extending for bonding the joints, their projections diminishing in the upper stories if lower stones are employed in the masonry, the quoins always projecting, but the bottom of the joint being frequently the face of the wall, sometimes having a slight projection.

The same principle naturally governs the intermediate lines of quoins.

If there be several stories, you will naturally mark their separation by horizontal lines. These are belts or bands, that in principle indicate the levels of the floors. Yet they are also frequently placed below thw windows, for which they serve as continuous sills. Such is the case of the magnificent Palace Strozzi at Florence (Fig. 142).

I cannot too strongly advise the study of this Palace; I know nothing in modern architecture, that presents in the same degree the qualities of antique architecture; absolute truth, nothing more nor less.

Note especially the proportion of the belts and of the upper cornice. I have spoken of cornices that crown the facade, also of belts that are nothing more than a projecting and moulded course, well marked but not competing with the cornice in height or projection.

The belt often has a general rectangular section with some mouldings beneath it. It is often ornamented, also being frequently preceded by a decorated frieze; such are the belts of Palace Farnese (Fig. 143), another masterpiece, or decorated without a frieze, as on Palace Pandolfini (Fig. 144).

The variety of bands or belts is infinite, and I cannot present a volume of citations, only saying that in mediaeval

architecture the belt is generally quite thin, since the course forming the belt has a great part of its height occupied by a steep wash (Fig. 145). Water and snow are enemies of belts, often like cornices; those projecting and rather flat should be covered with metal,-- generally lead,-- to protect them from leaks. Thus at the Chapel of Versailles it has been necessary to renew a considerable portion of the facade removed by rains, the recurrence of these accidents being prevented by lead coverings.

As for cornices, I shall have to speak of them again in connection with the orders. For the present, I limit myself to showing you that on Palace Strozzi, Palace Farnese, on the Louvre next Rue de Rivoli, the cornice is in proportion to the entire monument, not merely to the upper story. Its amplitude is the reward of simple treatment.

Mediaeval cornices(Fig. 146) generally have less importance than in antique or Roman architecture. The chief reason is the projection of the gargoyles, which localize the protection of the wall from the fall of rainwater. They will be mentioned again in connection with roofs.

I can scarcely go farther now in regard to walls; too many elements of their study belong to what we have not seen before, doorways and windows, arches, columns and pilasters, panels, niches, etc.

The first stage has then been passed, let us stop a moment to reflect a little and also to dream.

Have you not been somewhat surprised? Are these studies what you imagined them? They probably seem to you slightly austere and dry enough. Yet reread all this and you will see already, that from all this is revealed an art composed of light and truth. In beginnings or rather for the beginner, art is in a latent state, but it is all there, just as the flower and fruit are entire in the bud, and I cannot speak to you of these first principles of architecture connected with construction, without the budding and blossoming of art, promising ardent novelties and the emotion of unknown enjoyment.

But this art will not be a capricious fancy, but conscious. It will have its laws -- for between these laws and anarchy is no middle term -- yet its laws will not be fences, and just because you have learned, may you do what is possible for

you to create in your turn. Your resources will be great, and if in the rapid inventory of the first treasure, the first entirely your own, you have already seen unsuspected riches, continue boldly and rapidly to take possession, without losing any part of your heritage.

Remember that in every study, the beginnings are of capital importance. Become permeated by the first principles, for this is the key required for all that remains to yoy to be learned.

# CHAPTER V.; OPENINGS IN WALLS.;

## Their Construction.;

SUMMARY.; -- Rectangular openings, jambs and lintels.; -- Very ancieht examples.; -- Width limited by the lintel.; -- Primitive expedients for enlarging them.; -- Inclination of jambs, corbellings.; -- The arch.; -- Different forms of arches.; -- Semicircular, segmental, pointed arches.; -- Imposts, voussoirs, keystones, intrados and extrados.; -- Jointing of arches.; -- Oval arches.; -- Jointed platbands.; -- Relieving arches.;

I limited myself at first to the solid wall; now we shall study the wall with openings, here again to examine the resources and means of construction.;

All openings made in walls are designated by the general name of opening.;

From the point of view of use, they may be simple openings never closed, or be destined to be closed by plain or glazed shutters, such as wooden doors or sashes, glazing, etc.; That has no immediate importance from the point of view of their construction, and you can at first consider an opening apart from closures, that might be comprised.;

The simplest and earliest opening was rectangular, a vertical interruption in the construction of a wall, terminated or covered by a horizontal lintel.; In very remote antiquity, such is the Gate of Alatri.; It is the doorway or the common window (Fig.; 147); the sides are termed jambs, and the member covering the opening is the lintel.; The lintel will frequently be of wood or of steel in ordinary walls, of stone in monumental construction.; The monolithic lintel being an almost absolute custom in antique architecture, that presents magnificent examples of it.;

But the limiting width of such an opening is soon reached; further, this mode of construction is particulatly fragile, the stone lintel resting on the jambs by short ends, loaded by the construction above it, forms bad conditions if the least inequality of settlement occurs, the more so that the vertical pressure stresses it by flexure. Hence broken lintels are frequently seen.; Among the ancients, the courses of stone being set dry and the walls founded on the rock itself, no settlement was feared, and lintels of 16.4 to 19.7 ft.; could

be employed, of very dense and homogeneous marble. But with our mode of construction the monolithic lintel is only adapted to small openings, giving it great height and with dense stone. It was thus frequently used in the middle ages.

We shall later see how these inconveniences of the lintel were obviated by means of the jointed platband and the relieving arch.

Men have also sought to diminish the length of the lintel by two means; a slight inclination of the jambs (Fig. 148), or by the addition of supports termed consoles or corbels. The last system was frequently employed in the middle ages.

The former is suitable for a permanent opening, but if it must have woodwork, since the axes must be entirely vertical, the effective opening for air and light becomes rectangular, so that nothing is gained by greater width at bottom. Also the frequent use made of these openings in tombs associates with them a funerary character.

As for the latter (Fig. 149), it is no less obstructive for the woodwork of the closure, and does not accent the opening by a freely defined form. It is merely an expedient.

These cannot much increase the width of an opening, and if architecture were restricted to the lintel, it could never attain great openings. Still may be seen in very ancient examples the traces of the difficulties with which architecture contended when restricted to the simple lintel. Thus at Segni in Etruria is a gate of coarse masonry, showing clearly the wish to make a wide opening with offsets, and the necessity for reducing it to cover it by a lintel.

At Arpino, successive corbellings cause the gate to really have no lintel, the form is almost pointed, produced by projection of each course beyond that, just beneath.

I should not have spoken of these attempts, had I not desired thereby to prepare you to properly appreciate one of those magnificent discoveries, that are a capital fact in the evolution of an art, as well as in the advance of civilization

This discovery is the arch with the vault, merely its extension. It has already been mentioned, but I now return to it in greater detail.

Is the arch the result of progressive attempts, the systematic realization of a fact revealed by chance, or is it a con-

ception of genius due entirely to the power of thought? Assume this problem to be set; with stones of limited dimensions to span an opening ten times as wide as the stones, and suppose that an unknown Archimedes could solve it, would not there be seen one of the most sublime and most fruitful inventions of human genius?

Whatever may have been, new and undefined horizons opened to architecture, that utilized them admirably.

The term arch is applied to any construction in masonry of curved form, intended to span an opening in a wall or a part too weak to resist by itself the load of the construction above it. Thus the function of the arch is to support and to transfer to resistant parts of support the stresses of the mass of that construction; its condition consists in its arched form and in its concentric jointing, whatever the nature of the materials emploued. The arch is not naturally in a condition of stable equilibrium; the pressures supported tend to deform it and to displace its points of support; these must then afford sufficient stability, proportioned to the width of the arch and the load of the supported masonry it sustains. The widths of the piers is the principal condition of this stability, but it varies according to whether these piers are more or less loaded, for it reduces to a question of weight; it is necessary that the stress required to displac the mass of the piers should represent a pressure greater than the thrust of the arch.

Two adjacent identical arches with a common pier are in equilibrium on that pier; for the end pier or an external wall of a section, the stability is doubtful (Fig. 150). The verification of this stability is a delicate question of construction, subject to numerous factors, and for its solution I can only indicate to you an elementary and empirical rule. Your safest guide will now be to observe the proportions found in numerous examples, remembering that an excess of prudence is better than rashness.

It is necessary to know well, that if the arch reserves vast resources, it is a dangerous means in the hands of imprudent or unskilful men, But here again the principle of the appearance of stability will preserve you from serious faults, for the appearance of a construction to command confidence,

its security must be evident, and your eyes will gradually become accustomed to recognize if this condition is satisfied.

There exist numerous forms of arches; the most natural and purest is the semicircular (Fig. 151). The segmental arch is that whose vertical piers intersect an arc, whose diameter exceeds the distance between the piers. The pointed arch is formed of two equal arcs with radius greater than half the distance between the piers, their centres being in the line of its imposts.

The proportions of the pointed arch are variable, but form three combinations.

1. Depressed and nearly circular arch (Fig. 152) with centres inside the springings.

2. The lancet arch (Fig. 153) with centres outside the span of the arch.

3. The equilateral arch (Fig. 154), intermediate between the two forms, with centres at the springings.

There are various capricious forms, like the stilted arch, where the arch is extended by short verticals; the lanceolate arch with centres higher than the springings.

Finally and especially in Arab architecture is found the horseshoe arch, circular or pointed.

The impost is a projecting stone, generally moulded, that terminates the pier (A - A, Figs. 151, 155), voussoirs being the wedge stones forming the jointing of the arch. The first voussoir at each side is named the springer, and the middle voussoir B is the keystone. The visible cylindrical face of the voussoirs as seen beneath is termed the intrados.

The number of voussoirs is always odd, producing the keystone. The jointing may be conceived in two principal ways; it is either with an extrados, i.e., the voussoirs are comprised between two cylindrical surfaces, the intrados being the inner and the extrados the outer one. This jointing is very logical, as the masonry aboce may slip somewhat on the arch and cast all its weight on the piers, and the voussoirs with radial beds act normally. Yet it always has the inconvenience of producing acute angles in the masonry of the wall, which are always bad.

The other mode of jointing represented here (Fig. 151, A, B)for the segmental and pointed arches, consists in adapting

the jointing of the voussoirs to the lines of the courses of the wall. Its drawing requires trials to make the vertical joints bond sufficiently, and that the contact plenes of the voussoirs may be sufficiently large.

Perhaps you will find in ancient works a jointing in which the stones are cut with reentrant angles, so as to form both voussoirs and horizontal courses, as in Fig. 156. This arrangement is vicious and should be rejected, for the stones almost always break at the reentrant angle.

The series of arches also comprises other forms, that are only variants of the former; thus are elliptical arches, the major axis being horizontal or vertical, oval arches with several centres, stilted arches, semicircular arches with centres higher than the springings. These various arches are less common, and their construction is governed by the same principles as the semicircular arch. Only note that when for any reason you are led to employ them, they must be drawn frankly different from the semicircular arch. An oval arch should not appear as a deformed semicircular arch. As for the ellipse, being geometrical with a given height and width, but one ellipse is possible for them. It is not the same for the oval arch, composed of arcs of circles tangent to each other and with centres in pairs, the number of combinations for a given height and width being infinite, though the number of curves will always be odd, with 3, 5, 7 or 9 centres, and necessarily symmetrical. The greater the number of centres, less abrupt are changes in curvature, and a sufficient number are used to prevent breaks (Fig. 157).

Finally, connected with the theory of the arch is the jointed platband. We return here to the rectangular opening; the monolithic lintel has been shown and reasons given, why it breaks easily and should be used only for small openings, in our mode of construction. Assume that the voussoirs of a segmental arch be prolonged to the horizontal line connecting the springings (Fig. 158), and then with all the stability of this arch you have the platband.

The jointing of the platband has the inconvenience of requiring acute angles at the intrados instead of the normal direction of the joints of the arch. Therefore this jointing has been reproached as a sort of disguise, applying to a

straight form the elements of curved construction. True, the platband is merely an expedient, but one so necessary to us, that it must be accepted, and its theoretical opponents have been practically obliged to employ it.

Another equally legitimate expedient is the relieving arch (Fig. 159). A rectangular opening is covered by a lintel or platband, evidently a weak and exposed part of the structure. If an arch above it takes the pressure from the lintel, that will have to carry only the filling between itself and the intrados of the relieving arch. This arch may be semicircular, segmental or even pointed, but is only possible if the solid wall to which it transmits its load is sufficient to resist its thrust. Thus it would be impossible above a corner window, unless the angle itself presents sufficient width. Relieving arches are not always above openings. Thus in general they are frequently placed above piers or walls for transferring the weight of the wall to more resistant parts.

It seems useless to add, that no reason exists for a relieving arch, unless it actually relieves something, but there are sometimes seen in your projects, and even in executed works, arches without motive intersecting a wall solid below and above. That is not only nonsense, but it may injure the solidity of the wall. An example of faults committed when reason does not control the design.

All arches call for the general remark, that the flatter they are, the greater their thrust. Thus for the same span and conditions, the platband will exert the greatest thrust and the pointed arch the least.

Finally, when arches are built of small materials, bricks, rubble or gritstone, these materials are not of voussoir shape, and the mortar joints are thicker wedges, so that the mortar determines the resistance of the arch.

## CHAPTER VI. APPLICATION TO DOORS, WINDOWS, AND VARIOUS OPENINGS.

SUMMARY. -- Isolated openings (doors and windows). -- Internal and external doorways. -- With one or two leaves. -- Arched doorways. -- Imposts and internal arched soffits. -- Rectangular windows, antique construction. -- Sills and mullions. -- Balustrades and balconies. -- Great openings and large glazing.

In the preceding have been considered openings without regard to their use. From this point of view, they may be grouped in two families; isolated openings in a continuous wall, i.e., doors and windows; openings grouped in a series and separated by simple piers, i.e., porticos.

This distinction is rather absolute, and you will frequently see doorways borrow the architecture of porticos, yet it is indispensable to avoid nonsense, of which there are too m many examples.

Doorways. -- Doorways are internal or external, closed or open. For the present in regard to open doorways, I have nothing to add to what has been said on the construction of openings. This kind of doorway is an opening formed in a wall, a simple passage.

For doorways serving to close an edifice, a portion of a building, a room or hall, a distinction is to be made between external and internal doors, not only for their architecture, as we shall see later, but also for their arrangement.

In an interior, excepting where monumental architecture is adopted for a vestibule, colonnade or gallery in stone, and forms an actual facade arrangement, the woodwork of the doors is placed in the plane of one face of the wall (Fig. 160), chosen by the architect from considerations of convenience or decoration. A, A are the jambs of the doorway.

In a plan a door in an internal wall is simply represented by a rectangular opening P in the projection of the wall.

It is not the same for an external doorway. Such doorways must frequently harmonize with the arrangement of adjacent windows; besides these doorways are generally larger and would interfere too much with the rooms if opening at the inne surface of the wall, so that they are usually arranged -- as we shall see for windows -- in the following manner (Fig. 161)

the jamb comprises only part of the thickness of the wall, and the woodwork is fixed in a rebate; inside is the splay into which the door opens. This splay is oblique, that the door may open beyond a right angle. The same arrangement is at the top, making the same section of the wall as in plan.

According to the thickness of the walls, these conditions may be varied; in very thick walls the architect may form a sort of shelter before the door by giving greater depth to the jamb (E, Fig. 162); but more frequently the splay is enlarged (F, Fig. 162) to improve the lighting of the room, amd so as to allow the leaves of the wooden door to fully extend against the surface of the splay.

The jamb, rebate and splay extend to the sill, which is usually made of a single hard stone, sometimes of marble. It frequently forms a step externally; it is indeed well that the sill of a door be not exposed to rain externally, and it should have a slight slope to remove the water falling on the door (Fig. 163).

A doorway is often preceded by several external steps, where there should always be a landing before the sill, for if the steps commence without a landing, this would be dangerous in going out.

The sill is not always raised, when it is necessary for the landing or sidewalk before it to have a sufficient slope to remove the water.

Doors have one or two leaves. Naturally the principal doors will have two leaves, an arrangement permitting ordinary use of one leaf, and the use of a double width by opening both leaves.

Arched Doorways. -- Most doors are rectangular, this being the form best adapted to the woodwork, and rectangular doors are alone practicable when height is limited.

Arched doorways are without inconvenience if remaining open, but when to be closed, various difficulties occur. The leaves must have their hinges in a vertical axis of rotation (Fig. 164), and these fittings can only be applied on the rectangular portion of the woodwork; the entire arched portion remaining separate. Further, with a splay, the parts a, b, c, on the arched portion will describe horizontal circular arcs and will strike against the splay, so that the door cannot be entire-

entirely opened. To remedy this inconvenience have been conceived back soffits(Fig. 165), warped surfaces giving the splay a form differing from that of the jamb. Several sorts of these exist, which you will study in stereotomy. Ingenious means, but only expedients, that also reduce the solidity of the arch.

Thus arched doorways are actually reduced to rectangular doors by combination with a transom, which is the name of a semicircular part, glazed or not, that does not open, the door alone opening from the sill to the transom bar (Fig. 166) Evidently this means is only admissible for doors sufficiently high to permit passage and the appearance of free movement beneath the transom bar. Indeed it is not sufficient for one to actually pass, but one must not be tempted to bend in order to pass through a door of sufficient height. Nothing is more disagreeable than a low doorway.

The doorway with segmental arch, if the splay be properly arranged, does not sensibly differ in use from the rectangular doorway.

Thus the simplest, most practical and convenient doorway is, rectangular. Few others occur in interiors, except in churches, vestibules of other monumental halls, whose architecture is sometimes governed by considerations of symmetry with the elements of facades. As a facade, the architect may be controlled by very legitimate reasons of variety or character. He then has to appreciate in what measure he must subordinate practical considerations to an artistic expression required by him.

Windows. -- Nearly everything said of doorways applies to windows. The external doorway is a sort of window extending to the ground.

The window also has its jamb, rebate and splay. It remains to see the construction of the part of the wall between the window and the floor. First take the ordinary window in the house.

The water falling on a window runs off rapidly; it should not penetrate the wall, and the sill should be of a single stone, which should project to throw off the water from the wall; it has a wash for the same purpose, and is sectioned like a cornice with or without mouldings beneath. But this

stone is easily broken and should not extend into the jambs, whose unequal pressure might break it(Fig. 167).

This sill is sometimes merely a part of a continuous belt extending below the piers(Fig. 168).

The section of the sill should be arranged to prevent entrance of water beneath the woodwork, as in Fig. 169.

Yet in antique architecture, just as we find the monolithic lintel, we see the sill extending into the piers and without projection. I have already stated why settlement was less to be feared by the ancients; as for the projection of the sill, this was less necessary in the climate of Greece or Italy. Antique windows were frequently constructed as in this example (Fig. 170); sill A, jambs JJ, lintel L, the piers being of stone at P or rubble at B. It is important to know this arrangement, for we find there the origin of the decoration of windows. For us, the sill without projection is logical in but two cases; when the window is protected by strong projections, as in a story surmounted by a balcony, or when the window is under the portico.

Since the window does not extend inside to the floor, it is desirable to approach as near as possible to the outside to enjoy the air and view. Thus the solid masonry beneath has only the thickness of the jamb and the rebate, while the splays extend to the floor. This thinner masonry between the sill and floor is termed "allege"(in French). The section of a window is then represented as in Fig. 171 indicating the allege, sill, lintel, jamb, rebate and splay.

By this arrangement you will see in old books, that windows are indicated in plan as in Fig. 172. A ground plan was then made and therefore cut through the allege. To better indicate the windows on the plan, a horizontal section is taken above the sill (Fig. 172).

If the window be very high above the floor, the allege is omitted, being too high for its small thickness, and being useless, since it is not necessary to look out. The wall is then solid beneath the window, but generally to increase the admission of light, the inside of the sill is splayed with a section as in Fig. 173, this splay being cut in the sill or formed of other materials. Its slope is more or less according to the special needs.

Ordinary windows generally have two leaves, single leaves being only used for small openings for lighting closets, storerooms, etc. ( Casement Windows),

Yet the art of constructing wooden sashes with two leaves that shut tight is relatively recent. The shutter was alone made for a long time, a sort of small glazed door. These were mullion windows, i.e., a large window was divided into two or more compartments separated by stone mullions or bars. These were actually small windows reduced to dimensions permitting a sash in a single leaf. Fig. 174 shows a mullion window from the House of Consuls at Chartres.

In our time has frequently been reproduced this arrangement, charming examples of which exist. But it must be recognized that a very graceful window of this kind is incinvenient and lights but little; and while by taste or fashion it is often constructed today, it is very common for the inhabitants of old houses, more careful for their comfort than the appearance of their facade, to remove the mullions and bars in order to enjoy the more agreeable sash in two leaves.

Arched Windows. -- What has beensaid of arched doorways applies equally to windows. Here also the rectangular window is simplest, most logical and convenient. But the architect will appreciate in what cases various artistic exigencies will require of him the use of the semicircular or segmental window, etc.

Balustrades and Balconies. -- We have seen that the window differs from the doorway in not extending to the floor, hence the sill and the "allege". When the sill has the actual height of about 3.28 ft. from the floor, the window is thus complete. But frequently far better air anf light as well as for considerations of the facade, this height is not always given to the sill. Yet something should prevent a fall and permit leaning against it. Sometimes a simple straight bar extends between the jambs, or a balustrade or balcony is provided.

A balcony is any projection in stone or metal forming the sill, not only inside the form but projecting from it. The actual balcony is limited to each window., like those rising above each doorway of the monuments on Place de la Concorde at Paris (Fig. 175); grand balconies extend before several

windows and piers.

Generally the balcony is so arranged that one may remain there, and thus the window becomes a casement window, or actual glazed door; grand balconies cannot be otherwise conceived. Yet the casement windows do not extend to the floor itself, the balconies being usually raised one step above it. When the balcony railings are of metal, wrought or cast iron, they are capable of infinite combinations; when of stone, they bear the name of balustrade. There may be balustrades of very varied composition, but the ordinary and the most monumental result from the use of balusters.

Balusters are small round or square supports, close enough to ensure safety of persons, supporting a rail of stone or marble, and resting on a plinth. The entire height of plinth, balusters and rail should be about E.WI ft., or sometimes a little more, but would be dangerous if below that height.

It is easily understood that these balusters -- or any other stone filling, unless exaggerated -- forms a rather precarious and easily overthrown enclosure. Thus it should be only one panel. The stability of a balustrade is in the pedestals, that at proper distances connect the plinth and rail (Fig. 176), whose distances should be small enough, that the rail may be in a single piece from one pedestal to another without joints above the balusters.

The plan of a window balustrade will then be as in Fig. 177. The projection of the balustrade will then be supported either by a belt crowning the thicker wall of the lower story as in Fig. 178, or a balcony on consoles more or less projecting. The space between the pedestals and occupied by balusters sh should be the same as that of the window, or a little more, but never less.

As for grand balconies, whose projection attains great proportions, the appearance of security as well as construction requires them to be borne by strong consoles. But these consoles must only increase the stability, which is first ensured by incorporating the balcony with the facade wall. A balcony is nothing but a course of the wall projecting more than the others (Fig. 179). Before openings the balcony stone must be monolithic and extending a little into the jambs, so that the weight of the construction above it prevents it from

tipping, which may likewise be opposed by iron anchors.

When the balustrade of a grand balcony is of stone, it is evidently less fixed than for a small balcony, not being connected with the front wall at each side of a window. Then are required supports or pedestals above strong consoles; between the pedestals are blocks, and between these are balustrades or other panels. Here is a theoretical arrangement of a balustrade for a grand balcony (Fig. 180), showing the pedestals, blocks, balusters, large consoles and modillions.

The rail and plinth extend around the pedestals, but the top of the rail should always be smooth; ornaments in relief, vases, spheres, etc., are sometimes placed on the pedestals, but this is very inconvenient and opposed to the purpose of the balcony. Such decorations, if used, should be reserved for the end pedestals. An example shows the combination of all these conditions, the doorway of Palace Sciarra at Rome with a balcony above it(Fig. 181).

Grand Windows. -- Besides ordinary windows, the composition of an edifice frequently requires great openings for light, as at the end of a vaulted hall or a vaulted bay. Such are the great windows of churches, the great rese windows, the grand glazed arches of railway stations, waiting halls, etc. These types are extremely varied, and are governed by no rule other than the judicious satisfaction of the requirements. Generally, these openings are at a height not permitting leaning against them, so that their sills do not correspond to any human need; but since the great glass surfaces receive a great quantity of water, its removal must be particularly foreseen; this will be by means of pronounced slopes externally with projecting sill and drip.

These great openings cannot be closed by simple woodwork, but may be in compartments in any manner. Such are frequently by stone divisions, like the great rose windows of churches, thus obtaining panels of proper dimensions. But oblique or circular divisions, etc., if perfect for fixed glazing like church windows, do not lend themselves to the requirement of parts to be opened. Hence when you compose these great openings, you must see whether they serve only for lighting, for which fixed glazing suffices (except for external cleaning), or if these openings must also ventilate. In the latter

case, the divisions must be adapted to movable sashes, and consequently with horizontal and vertical combinations. It is well to make access to them as easy as possible. In most closures of the great windows of churches the stone divisions forming mullions and arches are very delicate and fragile. Thus frequently the iron armature enclosing the glass makes the stonework stable and suppoeted. It is better that the stone may suffice alone by the connection of properly supported parts; the stonework then almost becomes woodwork.

Among a multitude of examples of these arrangements, I shall limit myself to placing some before you; one of the grea side windows of the S. Chapelle at Paris, or those of the Church of S. Pierre de Louviers (Fig. 182). In a nearly analogous form of opening, but with notable differences in design, is a window of the Campanile of Florence (Fig. 183). Then in much wider proportions in relation to the height, consequently requiring more numerous divisions, I cite the windows of the bays of the Hall of the Synod at Sens, and the great window at the extremity of the same hall. (Fig. 184). Finally, if we pass from that to the great rose windows, no less varied, the rose window of Notre Dame above the South portal, which you may see externally and internally (Fig. 185); also that of the S. Chapelle of the Palace.

I could not show you these combinations without at some time having you see the decoration that they suggested, being a little in advance in that respect; we leave this to return no more to what has been said.

## CHAPTER VII. DECORATION OF DOORWAYS AND WINDOWS.

SUMMARY. -- Antique origin. -- Jambs and lintel, architrave and ears. -- Caps. -- Antique doors of Cafalu. -- Caps with consoles. -- Doorways with pediment caps, enclosed by columns or pilasters.

Decoration and character of arches. -- Antique arches of Falerii and Perugia. -- Arches richly decorated. -- Principles to follow. -- Arches in Latin and Byzantine architecture. -- Romanesque arches. -- Gothic arches.

Comparison of tendencies of antique and mediaeval architecture.

Decoration of arched windows.

Resume the rectangular opening. Its original construction comprised first the lintel, at first supported by stones set on end that formed the jambs, perhaps from tradition of simple construction in wood with posts and beam. These special stones must be properly dressed in the midst of ordinary and sometimes rough construction. Mote the architrave (moulded band around the opening).

But the lintel needs more strength and is higher than the width of the architrave, its length extending beyond the jambs. Thus the ears (Fig. 186).

Hence in principle, the architrave is a flat enclosure with only some border mouldings; by its enclosure the ear is accented and ranges with the top of the opening.

Such are the theoretical elements, that should not be forgotten, even when you vary from them. You may see in the Schoo of Fine Arts several doorways studied with architrave and ears combined in absolute purity.

But rain is always an enemy. Whether the opening be a door or window, it is important to preserve it. How? By a cap, as for the wall. There are examples of doorways where the cap is placed directly on the architrave; such are the windows of the Temple of Vesta at Tivoli (Fig. 187), with a very beautiful study of architrave and profiles. Particularly one of the doorways of the Temple of Diana (?0 at Cefalu (Fig. 188), whose architecture expresses the theory just stated; again another doorway of the same monument (Fig. 189).

It is interesting to compare these examples with a pretty

Renaissance doorway at Corneto, composed in the same spirit in a very elegant study (Fig. 190).

Though the rain be thrown off by the cap at top, it is still injurious, for it always falls before the opening, particularly if this be a doorway, when it falls no less on the persons entering or leaving. Then it would be useful to throw the water laterally, and hence the doorways were covered by a triangular or circular pediment.

Then I reject the criticisms by certain purists in regard to pediments crowning doorways or windows, under the pertext that the pediment is the end of a roof. Doubtless, but from the moment that the use of an architectural form has a motive, where it is logical and useful, it escapes all criticism.

Hence, architrave, frieze, cap and pediment form a complete decoration of the external doorway. Beautiful examples abound; I cite one of them, which is the grand doorway of Church S. Jacopo degli Spagnoli at Rome (Fig. 191). This is mentioned in preference to any other, because I know none more beautiful. I add only that in examples taken from the purest architecture, the pediment is not found over doorways not exposed to rain. Since this motive has become especially decorative it has likewise been employed in interiors as on exteriors. It is useless to repeat, that it is all the same for doorways or windows, except the railing or balcony, already mentioned. Therefore I shall speak indifferently of both.

Architraves with ears have also given rise to combinations varied by the addition of friezes, caps, etc., as on a doorway of an antique Temple at Agrigentum or another at Tivoli (Fig. 192), or in a very great number of examples in modern architecture, which it would be tedious to enumerate.

As for doorways and windows with straight architraves, with caps and with or without pediments, beautiful examples are extremely numerous. One cannot turn over a book without meeting them. I will cite some.

On the exterior, the doorway of the Pantheon at Rome (Fig. 62), several doorways of the Vatican, the windows on the court of Palace Spada at Rome, those excessively rich from the Certosa at Pavia; in the interior, the doorway of the library in the Cathedral of Siena (Fig. 193).

To give greater monumental breadth to the motive of the

doorway or window, the cap is frequently extended beyond the line of the architrave and then made to project more by means of consoles supporting its ends. This beautiful motive is often falsified in the design, and as always, I direct you to its origin, and you can work with knowledge of its motive.

Our doorway (Fig. 194) is always covered by its lintel or jointed platband. Outside that lintel or platband, you can place a console, a high and narrow stone fixed in the wall, whose upper projection supports the cap after the fashion of a balcony, i.e., under the cornice.

Such is the theoretical arrangement, which calls at once for various remarks.

1. The console must be sufficiently far from the jamb of the opening to permit the construction of the lintel, the more so since in the interior the opening will be wider on account of the splay.

2. This console should not extend below the joint terminating the jambs, for if prolonged to B, the lintel would rest on the small and weak block of stone without bonding at the joint.

3. If it be desired that the upper moulding of the console should be enclosed by the angle of the cap, this cap should extend little beyond that angle. If the projection C,D, be increased, it must also be increased in front, and the cap will then have an excessive projection, or not have equal projections in front and sides, which would be a mean arrangement.

4. For the same reason, it suffices for the console to be crowned by a simple moulding; if you desire a richer moulding of the cap, it is natural for the lower moulding to stop between the consoles.

5. In general, the opening is enclosed by an architrave, and frequently above the consoles is another architrave. The theoretical scheme of the window is then that of Fig. 195. Note only that the upper architrave is sensibly narrower than the lower one.

Must you restrict yourselves within absolute rules? No, but at least you know when and why you depart from them.

You will further find in the beautiful examples the observation of the more essential principles; width of architrave, with or without ears; frieze often decorated, thin and elegant

consoles. Study in antique architecture the doorways of the Temple of Minerva Polias -- an architecture still beautiful, of the Temple of Jupiter at Cori (Fig. 61), and of the Basilica at Palestrina (Fig. 196). In modern architecture turn at once to the walled up windows of the pavilions of the School of Fine Arts; Duban is the architect, who with the most taste is also the most theoretical in the study of forms. Then study the composition of the windows of Palace Sachetti (Fig. 187), the doorway of Palace of Venice at Rome (Fig. 198). See the magnificent windows of the court of the Louvre (Fig. 64), etc., etc.

Finally and nearer us, I recommend for your study the charming doorways of the pavilion of music at the Grand Trianon; I take this occasion to show you a sketch of the whole of that pretty little edifice (Fig. 199).

You will again find numerous rectangular doorways and windows, whose opening is enclosed by two columns or pilasters supporting an entablature. This is a sort of porch around the opening. This motive was already in use on Roman architecture, particularly on the altars of the Pantheon, and it was in great favor with Italian artists of the 16th century. But its element is the order, the colonnade, and I do not wish to begin the study of the orders by one of its least applications. Yet I must now indicate to you some beautiful examples of this arrangement; thus the windows of Palace Farnese cited previously (Fig. 14), and by name others well known and taken here and there; at Catania, the richly decorated doo way of the Cathedral; at Venice the windows of the Procuratios an internal doorway of the Palace Doge, etc.; finally a window of a palace of Florence, where the opening is surrounded by an architrave enclosed by two hermes pilasters with entablature and pediment (Fig. 200). I shall only say here, that in this case, the arrangement forms the true enclosure of the doorway or window, and that the simultaneous use of the architrave then forms a superfluity, though frequently an element of great richness.

It is also necessary to remember that this mode of decoration is possible, when you can command sufficient projection to allow it.

In each of these parts, the theme has been infinitely varied

in the same edifice, the necessary variety is imposed; then is the consideration of the severe or elegant character of the architecture; the use of different materials, richness with simplicity.

I can neither show nor cite all to you, and shall no longer dwell on the theory of rectangular dooeways and windows.

We will now observe the expression of architecture in the design of arches.

Recall what I have said of the construction of arches; their elements are voussoirs, keystones and imposts. This construction itself is the decoration, or rather the expression of the antique arch in all its purity.

As first examples, I will cite two gates of high antiquity and great beauty, those of Falerii and of Perugia.

At Falerii (Fig. 201) the arch is composed of voussoirs of great dimensions and has an extrados; between this and the masonry of the horizontal courses is a second and thinner series, whose stones are not properly voussoirs, its motive being a moulding enclosing the archivolt. Then in this entirety are stones with special junctions and meriting decoration more than the others, the imposts and keystone, decorated by mouldings of beautiful profile, the latter by a sculptured head.

Observe this arch; others have been made since, but the style of this has never been excelled; in our modern architecture the most beautiful arches approximate this style. Why?

Because perfect identity exists between decoration and construction; because the style you admire is the truth of that beautiful architecture, all of which has its motive, all is just and legitimate. This magnificent quality of antique architecture is found in its beautiful works, and it is thus since it could not be otherwise.

At Perugia (Fig. 202) the conception is still the same, except that there are two concentric archivolts and also the series of enclosing mouldings. The keystone was decorated, but the imposts are only expressed by the projection of the piers beyond the surface of the archivolt.

This gate is also of high antiquity, being erroneously called Gate of Augustus on account of the inscription "Augusta Perusia". Augustus only caused the massacre of the inhabitants

of Perugia, placing his name on the city repeopled by his executioners. It is better known than that of Falerii, likewise very beautiful; it results from the same art and the same principles.

These principles are perpetuated through all transformations of styles, being so true and pure; accenting of imposts and keystone, decoration of archivolts by enclosing mouldings, leaving to the voussoirs all their strength in reality and appearance. Such is the traditional arrangement, even when the jointing has no extrados, and excepting the case in which the decoration only consists in the jointing itself, whether plain as on the Theatre of Marcellus, or accented by sunk joints and bosses.

Even when the archivolt is decorated, it is always interesting in what it may be in respecting these principles; thus one of the most beautiful examples of a decorated archivolt is furnished by the principal arch of the Fountain of Trevi at Rome (Fig. 203); a continuous ornament indeed occupies the face of the voussoirs, while leaving to the archivolt its character of unity and strength.

It is true that archivolt are frequently divided into two or three concentric rings by bands projecting beyond the others. Yet these projections are slight and allow the character of unity to remain, without which if they were too much accented, if the archivolt thus loses its character of unity, you may be sure of being before a work of the decadence.

In Roman architecture, then in that called Byzantine and finally Latin, may be frequently seen arches without any mouldings to accent the forms, it being then accented by the combination of materials. For example, the impost will be of one or more courses of bricks making a horizontal line of color. The archivolt is constructed of stone or rubble enclosed by a row of end bricks (Fig. 204). With other means it is still the application of the principles just stated. These combinations are also susceptible of a certain variety. Thus sometimes, notably in Byzantine architecture, the stone voussoirs are separated by bricks whose color clearly marks the concentric direction of the jointing. One is frequently inspired by that arrangement in contemporary architecture, particularly in educational buildings.

The intrados of the archivolt is often decorated with more or less richness, almost always with the same feeling for unity and continuity, which is the character of the intrados as well as of the face of the archivolt. But the ornamentation must be quiet in any case. The part of the arch in any construction is always that of the supporting element, and as such should be strong. This will be its true character. We shall later find the same character when considering architraves.

Finally, the arch is often decorated by an architrave, that I believe to be merely an architectural imitation of rectangular gates, and the vertical architrave has small reason for being with the arch. There are some examples in antique architecture, of little importance or value. Nearer us must be sought the most beautiful models, especially in Florentine palaces; first being Palace Strozzi. Then see the doorway of the Library of S. Genevieve and that of the School of Fine Arts. Yet the architrave is not a motive applicable to great arches, and I cannot become accustomed to the architraves of the great arches of the Railway Station du Nord.

I have again spoken of antique examples, thus passing to modern examples without a transition, since these proceed directly from the others. Between these are the mediaeval arches, whose study is no less important, for mediaeval architecture employed the arch as its chief means of construction. Without now examining the various functions of the arch, which have given it the names of transverse, diagonal, side arch and flying buttress, I limit myself to the arch in a wall as in the preceding.

Romanesque architecture employed almost entirely the semicircular arch, at first very simple, then sometimes very ornate. But we will not allow ourselves to be distracted by the ornamentation, but observe the architectural part.

If the arch be single, there is no difference between the Romanesque arch and that of Falerii, unless in sections of mouldings, always a secondary matter. The difference is rather in the pier, rectangular in antique architecture, generally lightened by columns in Romanesque architecture. This practice may be judicious or dangerous, according to use; if the arch rest entirely or nearly on the column (Fig. 205) and is

somewhat loaded, there will be a chance of crushing it. On the contrary, if it have sufficiently deep voussoirs, so that the pressure be carried to the pier beyond the column, there is nothing to fear (Fig. 206).

Most frequently in the great edifices of that epoch, you see several arches -- two, three or more -- recessed beyond each other, and if seen from beneath exactly representing curved steps. Referring you to the Gate of Perugia, assume that the two arches or rather the two archivolts of Perugia were not in the same plane, the smaller receding behind the other, this would be the Romanesque arch with several archivolts (Fig. 207).

As a construction, Perugia is logical, these superposed archivolts assume considerable weight to be borne, and stepped archivoltd are possible in a thick wall. Except in special cases this wall has its centre of gravity in its axis, and at Perugia its pressure is in equilibrium on the equally loaded arch. It is not the same with the Romanesque arch. The thick arch is in equilibrium, but not the thin arch, and the thick archceases to be in equilibrium if the thin arch serves to support the construction above, however little. Exaggerating the recess (Fig. 208) and assuming the wall to rest on the thin arch; this resistance being outside the gravity axis, the thick arch will tend to yield at the unsupported side.

Then it is erroneous, as many authors have done, to attribute value as supports to stepped arches. On the contrary for good construction, it is necessary for the thick arch to be able to bear the load of the wall above, the thin arch supporting nothing.

Then assuming the Arch of Falerii, and that below and behind the face of that arch are one, two or three successive stepped arches, the whole will be as solid as at Falerii, but with a useless addition.

Why that addition? For several reasons. Perhaps for centering, difficult for a great arch, easy for a small one. In Romanesque architecture the steps are not so pronounced as in the preceding sketches. Assume steps such that the centre of gravity of each certainly falls within the preceding archivolt (Fig. 209), and when archivolt 1 is complete on the wooden centering, it serves as a centering for 2, etc.

But particularly these stepped archivolts form a shelter and a porch. The door or window is beyond this porch and far from rain, and the motive has a decorative flexibility that perfectly justifies the arrangement, on condition that one learns just what he is doing, when he has recourse to it.

As for arches constructed as in the sketch (Fig. 210), such as sometimes found in irrational imitation of Romanesque architecture, and perhaps in that architecture itself, it is simply bad construction.

In Romanesque arches the intrados is not decorated, with perhaps some exceptions. These are at an acute angle with the face of the archivolt, or rather the angle is replaced by a round moulding (Fig. 211). As for the face, after being smooth as in the older monuments, it ended by being covered with various ornaments, often contradictory to the feeling of the construction, like chevron or billet mouldings.

Finally, stepped arches naturally result in stepped piers, and then by the custom of resting each arch on a column, we arrive at the well known and very decorative motive of the Romanesque porch. This arrangement is rich in appearance, often carried to great elegance as on the beautiful porch of S. Trophime at Arles, or the portal of the Church S. Croix at Bordeaux (Fig. 212); but this delicacy is only justified if these steps do not bear the weight of the construction above, that would crush the columns.

If you have recourse to this motive, think carefully of the construction as always. Note the function of the arches, effective or decorative, and arrange that bearing arches are supported.

By insensible transitions, Romanesque architecture became Gothic architecture. The arch is drawn with two centres, at first very near other and then more distant. Volumes have been written on the origin of the pointed arch; this is not my domain, but I study it as it is, where I find it, and whence it comes. I shall also have occasion to speak of the pointed arch in more detail, when treating of religious architecture.

The pointed arch at first presents the same characteristics as the Romanesque arch, the archivolt being clearly indicated. This appearance is also found in Italian pointed arches at

Florence, Siena, etc. But as the middle ages became more assured in the possession of its methods and took more confidence in itself, boldness became the quality most sought.

Then the archivolts were recessed more, until great hollows ended by giving arches an appearance of an acute section (Fig. 213).

At the same time, the arch passed farther from the starting point of its study -- which was the simplicity and emphasized vigor of the structural element -- the arch became the theme of the greatest richness, sculptures of saints with pedestals and pinnacles; figures cut in the solid ended by being prepared in the studio, and were set by the aid of cramps in the recesses of the architecture. The richness is amazing, but the architectural element has somewhat vanished to give place to the statuary element. See especially the magnificent portals of Notre Dame, of Rheims, Amiens and so many others, whose infinite variations I cannot explain, numerous examples of which have been shown.

Yet viewed in general and by the combination of recesses, these grand church porches retain a grand appearance of reassuring stability. All this development of archivolts arouses the idea of great breadth of vaulted construction. Indeed the elements of this construction are lost from view, p partly masked by the statues, but one feels its existence; if not presented to the eyes as in the antique or the primitive Romanesque arch, if no longer the art of simplicity, it is an admirable art so long as it does not revolt against the requirements of construction, so long as it is governed by the same principles that we have seen in Grecian art, so long as its works are as they are and could not be otherwise.

The arch has such importance in architecture and its function is so characteristic, that this element alone suffices to determine the styles. From the antique architecture of the Gate of Falerii to the end of the middle ages, the gradual and continuous evolution of architecture is manifested by the design of the arch.

The arch permits you already appreciate the difference between the architecture of antiquity and of the middle ages. Both are necessarily dominated by the laws of construction. But antique architecture accepts construction as artistic

direction, conforming to it loyally and without resistance, requiring skill in execution, but its conceptions are simple and easy; it does not haggle with stability, but ensures by its proof.

More skilful, ingenious and also more complicated, mediaeval architecture does not escape the rule of construction, but rather permits than accepts it, seeks the minimum of material in both reality and appearance, employs great experience in construction to struggle against requirements and almost evade its laws, loses boldness, and is not displeased because the stability of its works astonishes observers.

Thus when the time came for antique architecture to perish, it did not perish for its principle; on the contrary, prudent sagacity and respect for stability enabled it to survive, when the ignorance and decadence of a decayed civilization had lost all its skill, and even extinguished the arts and trades; while Gothic, faded and exhausted by the exaggeration of its tendencies and skill; when increasingly mistress of its means and trusting to audacity, it pursued the unrealizable and the admiration of feats, when it no longer lived except by dexterity and not by principles. Antique architecture fell by the invasion of barbarism, Gothic architecture vanished in the ful progress of civilization.

In the preceding, I have especially spoken of great arches, omitting until later the arcade portico. The isolated arch, doorway or window frequently borrows its architecture from the portico; such are the arches enclosed by columns and entablature. We shall return to this in treating of the orders.

Yet I must again cite some beautiful examples of doorways or windows so conceived. They are innumerable, but it suffices to indicate the doorway of Palace Cancellaria, that of Palace Sciarra (Fig. 131), an internal doorway of Palace Doge and that of Palace Camerlinghi at Venice, the pretty windows of the court of Palace Doge next S. Marco, the doorway of Chateau of Ecouen by Jean Bullant (Fig. 214), finally one enclosed by caryatids instead of columns, the celebrated doorway of the City Hall of Toulouse by Puget (Fig. 215).

The arched window is common after the middle ages; then it is naturally enclosed by an archivolt, the jambs being often treated as little columns. These elements were already men-

tioned.

Since the Renaissance, the arched window has frequently been treated with elements analogous to those of the rectangular window, architrave, cap with or without frieze, and sometimes consoles. Considerations are nearly the same, and I cannot do better than indicate the arched windows of Palace Ca cellaria at Rome as masterpieces of taste and design (Fig. 216

Then the doorway and window with semicircular or segmental arch played a very important part in French architecture of the 17th and 18th centuries. Fine examples exist at Versailles on the Palace, and those of the chapel are treated rather as arches in a portico (Fig. 217). You cam see the doorway of the Palace of the Council of War at Paris, the windows of the great pavilions of the Louvre next the Quay, and a great number of other examples in the old mansions of the Marais or of Faubourg S. Germain. I can only show you the less known doorway of an ols mansion at Dijon. (Fig. 218).

The arch, by its construction and function calls for bosses and sunk joints, and numerous examples exist. In antiquity is found Gate Maggiore at Rome, but especially in the Renaissance was this motive employed with such breadth and style, either as a doorway whose value is in the jointing, like those of Palace Farnese at Rome, Palace Pandolfini at Florence, or that of Villa Medici; or these doorways were accompanied by columns, like the gateway of the old Farnese gardens at Rome, that of the oval court of Fontainebleau, of Fort S. Andrea at Verona (Fig. 219), a masterwork of San Micheli, or by pilasters like those of the Caprarola and of the gallery of the court of fountains at Fontainebleau; I cannot review every variety of combination tried by artists, always the same and always novel for real talent.

Some varieties of windows are to be treated, elliptical or rosette, trefoil or round; all these require no theoretical considerations, any more than niches. Dormers will be mentioned in connection with roofs; for the present I continue with the very elementary subject of an opening in a wall. The isolated opening has been examined, and I come to continuous openings, i.e., porticos, which will be the subject of the next book.

# BOOK IV. ELEMENTS OF ARCHITECTURE.

## II. GROUPED OPENINGS OR PORTICOS. -- THE ORDERS.

Porticos. -- The antique order. -- The different orders.
Arcade porticos.

## CHAPTER I. PORTICOS AND THEIR CONSTRUCTION.

SUMMARY. -- Piers and their various forms. -- Arched porticos; resistance of angles. -- Porticos abutted by buildings, on facades or in courts. -- Porticos on circular plan. -- Superpositions.

Foresight required in the study of the plan.

Porticos have been defined as Aopenings grouped in a series and separated by simple piers". In principle a portico is not closed, but if glazed, it still retains the character and design of an open portico. Then in this primary theory of the portico, it must be assumed as open.

First examine the pier.

The primitive form of the pier was evidently square, stones being set on each other or a monolith with four sides made the pier. Connecting one pier with another by lintels or arches produced the portico.

But the square pier obstructs passage, its angles are rounded off, being nearly useless in construction. Hence fromthe polygonal was necessarily attained the round pier, the column.

All fancies deriving antique colonnades from the memory of forests, of the cabin of tree trunks, etc., are purely imaginations of poets or archaeologists. The truth is more practical and instructive. *

** Note. For a long time the theory of the hut was in much favor, and is found particularly in the Dictionnaire of Quotremere de Quincy (who was not an architect). M. Leseur has fully demonstrated its stupidity in his course on theory.*

The cylindrical pier or column may also support lintels or orders, formimg colonnades or arcades.

From the point of view of construction, what was said of arches, lintels and platbands in speaking of openings, equally applies to porticos. Yet one observation is important for arched porticos or those with jointed platbands.

While an opening made in a wall always has piers at right

and left, whose mass neutralizes the thrust of the arch or platband, permitting the use of that mode of jointing without danger, this is not so with the portico forming alone a facade. Assume an arrangement like this (Fig. 220); at h the thrusts of the arches are neutralized, and all stresses have as resultant a vertical along the axis of the pier, making perfect conditions. But at B nothing resists the thrust of the arch outwards, and this thrust combines with the weight P of the construction above to give an inclined resultant R, hence the overthrow. Not a localized overturn, since if the first arch fails, the second is then in the condition of the first, and thus continues the entire failure of the facade. A new proof of the importance of the angles.

Instead of arches assume jointed platbands and the result will be the same but more to be feared, since the platband exerts the greatest thrust of all arches.

Thus when you see an arrangement of this kind with arches, like that on Palace Doge of Venice (Fig. 221), be assured that some artificial means must have been employed to suppress the thrust; on that monument are visible iron tie-rods. This means has been frequently employed and is not to be condemned; yet it is more logical and has a better effect for security of appearance, to make the angle piers different from those intermediate, and sufficient of themselves to resist the thrust (Fig. 222).

For jointed platbands the difficulty is greater. The simple tie-rod is no longer possible, or it must pass through the voussoirs to connect the imposts. This was often done at the Pantheon in Paris (Fig. 223). Holes in the stone are filled by iron bars, doubly dangerous, injuring the stone and also liable to rust, expand and burst the stone, a frequent accident. For colonnades the only practical and rational method is the monolithic lintel, always employed by the ancients, whose forms have been frequently borrowed without borrowing wisdom in their use.

Nothing better than the Pantheon can show what difficulties are encountered by desiring to violate the laws of construction in architecture. I respect the work of Soufflot as much as anyone, it being very remarkable in many respects, but having at command small materials, he desired to reproduce a

colonnade of very great dimensions; the means are ingenious and scientific, the result may be astonishing, and doubtless when a work is beautiful, an account of the means used may not be required. But an artificial work must be precarious; antique colonnades have all the eternity, that human works may promise; if we must reproduce them -- and I do not oppose -- at least have the courage to resort to antique means, alone in harmony with their composition.

It is not the same if a portico be placed between resistant pavilions, as on the beautiful monuments of Place de la Concorde (Fig. 59). The mass of the pavilion neutralizes all thrust acting in arches or platbands, and for the portico only the stability of its elements is necessary.

Likewise in a court, when internal vaults resist the thrust of the arches. Assume a plan with arched portico next the court (Fig. 224). In two directions internal arches exist on the extended lines of the columns; beyond these arches are solid walls forming actual buttresses; stability is then assured, although the angle pier may not be sufficient to ensure it. I will cite the court of Palace Cancellaria (Fig. 225) at Rome, one of the most beautiful examples of an internal court with porticos.

We shall later see in speaking of vaults what resistances porticos must ensure transversely. It is evident that the section and architectural form of the piers must very according as they are more or less loaded, more or less in danger of being overtheown. Thus in the plan of the court of the Cancellaria, the slenderness of the columns is only possible for two reasons; they are of granite with marble capitals and bases, and the thrust of the vaults is neutralized by iron tie-rods extending transversely. You will appreciate these considerations better after having studied the functions and effects of vaults.

On a circular plan the curve closes, and there are neither angle nor intermediate piers. All bays are in identical conditions, but all present the danger from overhangs inherent in all circular structures. Thus porticos requiring a sensible angle between two bays cannot be constructed. The little rotunda of the Trianon (Fig. 226), called Temple of Love, is a pretty example of a circular portico, realized without an

use of iron and only by skill in stereotomy.

Although the portico may be covered, the rainwater enters if assumed to be open. If it be in the ground story and simply over steps or a sidewalk, there are no difficulties; a slight slope is given to its pavement and to ensure its resistance to water. But if it be enclosed by balustrades in any story, outlets must be provided for rainwater. The quantity not being great, no leaders are necessary and several outlets suffice. Yet this is always a very delicate point of the study, negligence of it causing serious inconveniences.

Porticos are not always detached edifices, but often form a part of a facade in stories. We have seen them superposed on Place de la Concorde or again at the colonnade of the Louvre. They also exist in the ground story receiving an enclosed structure above. Such is the case on Palace Doge, previously cited, on the buildings along Rue de Rivoli, the Theatre Francais, etc. Then, provided the stone of the piers offers a sufficient resistance to the crushing produced by vertical pressure, this additional load increases the stability of the portico itself bu neutralizing the thrust of the arches or jointed platbands. Thus for these porticos stability may be precarious during construction, becoming definite when the upper stories are built.

Finally, porticos are often superposed on each other; then the upper portico increases by its weight the stability of the lower portico. Such are these of the facade of S. Sulpice or of many internal courts, like the court of Palace Farnese at Rome, or those recently demolished of the old Palace d'Orsay at Paris, a memory of which it is of interest to preserve (Figs. 227, 228).

Such are the primary data of the constructability of porticos. All this requires the scientific study of construction; I merely deduce some things in passing.

The more open your architecture, the greater need of prudence, which must increase in the study in accordance with the boldness of the results desired.

In the study of a plan -- once that the arrangement is fixed -- you should always and particularly think of the upper parts of the structure. A plan must be studied by elevating the eyes in thought. The upper parts control it.

A plan is never well studied, unless it may clearly appear to lend itself to construction in entire repose. A good plan necessarily permits good construction, for otherwise it would not be a good plan.

## CHAPTER II. THE ANTIQUE ORDERS.

SUMMARY. Column, capital, architrave; reconstituted wall. -- Portico of Caryatids at Athens. -- Entablatures with friezes. -- Function of each part. -- Composition common to the different orders.

The study of porticos reached its climax and established its principles in the antique orders. Before beginning with the antique orders, I will explain what an antique order is in its unity. The classifications called Doric, Ionic, Corinthian and Tuscan are only special cases of the same conception primary divisions from the point of view of character and style, and these may be infinitely subdivided.

At regular distances, primarily determined by the possible length of the stone lintels, are placed the shafts of columns, which are round, the form best adapted for passage and for light, and for avoiding shocks disagreeable to persons and injurious to the monument. This form is also beautiful. Most frequently indeed, the column is fluted, a traditional memorial of the transition from the square pier to the circular section the angles were removed to form the octagon, then passing from eight to sixteen sides, the number of flutes in the most ancient Doric orders.

This circular column is not a cylinder but at first a truncated frustum of a cone, then assuming a slight entasis, always smaller at top than at bottom. Is this a simple caprice or search for effect? No, for the construction demands it, the column being more loaded at base and less at top; larger and heavier blocks are best handled near the ground than to raise them to a great height, and through their upper intercolumniation chiefly passes light. Finally, the mind requires a pyramidal appearance, and so this architecture everywhere realized the absolute harmony of requirements never equalled by construction, with the esthetic satisfaction of the most perfect taste.

The column has an entasis, but not a regular surface by accurate generation, and it is never swelled. In modern architecture have been used swelled columns, a singular imitation of a column crushing under its load. The perversion came from the Vitruvian superstition by reading in Vitruvius, that the col-

umn exhibits at about one-third its height what the Greeks termed entasis, translated by swelling instead of convexity. If you desire evidence, compare in the court of the Louvre the admirable columns of the Renaissance portico with those later inflicted on the pavilion leading to the Quay. You will be cured on the malady of columns in form of cigars, temporary like all irrational fashions.

Above these columns must be constructed the continuous wall, which is the function of the architrave, though this does not rest directly on the shaft; this bearing would be issufficient, and the rounded column must again become a square pier to support the architrave. Thus it terminates in the capital, a last course, round at base to fit the column, square at top to receive the architrave. Then every capital is not merely an ornament but a support, always passing from the circular to the square in all combinations.

Thus are the columns constructed, properly aligned, spaced and on a level. From axis of one column to that of the next extends the stone architrave, a word exactly corresponding to main beam and termed epistylion in Greek, meaning on columns. These lintels are single in length, but are often two or sometimes three in width. So the architrave is a lintel (Fig. 229), composed of a rectangular section crowned by a fillet. When its section becomes complex, the merely rectangular section gives place to facias projecting beyond each other, yet retaining the original character, as already stated for the lintel, architrave and archivolt.

The wall is then restored, and we can proceed with a horizontal course, as if no openings existed beneath.

Much nonsense would have been avoided, if for the purely graphical and modular division of the order into column and entablature had been substituted a more real division, i.e., the colonnade and the architrave covering it, then creating a need for the protecting projection, i.e., the entirety required to receive the roof, for which the portico is covered.

But I have no desire to rebel against an expression accepted for columns, for names are of little importance if producing no changes, so I state that the architrave is the first part of the entablature.

What is found above the architrave again depends on the con-

struction, and will be first explained, aside from an anomaly to be mentioned later. I now treat of the final theory of the antique order, not of the phases through which it passe

There remains a unique example, that logically exhibits the conception of the entablature, the portico of Caryatids or Pandroseum of Athens (Figs. 230, 231).

Perhaps you will be surprised, that in regard to the antique order, I first mention an exceptional monument without the primary element of the order, the column, which is not without a motive.

You know that this monument is small and built against a building. As covering it only exhibits thick marble slabs, ceiling below and roof above.

Then naturally the ends of the slabs form the cornice set directly on the architrave with nothing between them. This construction dictated the architectural treatment.

But this course of slabs forming both ceiling and roof is exceptional, and less simple compositions were necessary in larger monuments.

There in the most rational construction (Fig. 232) ceiling beams were placed on the architrave, principal beams perpendicular to the facade and centering over the columns. These beams then do not permit a continuous course like a cornice course, since they support the compartments of the ceiling, to be studied later, and that do not allow the direct placing of the cornice on the architrave. Hence a wall course with openings for the ends of the beams, and sometimes composed of two slabs, or even left open.

This is the frieze.

The frieze is thus a first course of the wall above the lintel, has the character of a vertical course, and when decorated is always vertical.

It then remains to crown and protedt the wall by its cornice, as already seen for walls.

Thus the entablature consists of architrave, frieze and cornice, connected with the construction, the columns and entablature constituting the order.

The orders vary infinitely in their details and the gradation of their proportions. But this variety does not destroy the artistic unity of the orders, governed by the entirely

logical law to be stated.

I will exhibit first an example, rather ideal because so simple, and presenting no addition to the synthesis of the antique order, that of the Temple of Pietas at Rome (Fig. 233)

In presenting it some remarks are to be made.

You have already seen that the column is diminished from bottom to top, does not have a straight but slightly convex outline.

This requires a brief digression.

The Greeks were both very artistic and very prudent, had little variety in their architectural motives, were much attached to tradition and yet had a free spirit, but were still primarily artists slowly and surely perfecting the works of the past. They felt no need to create new elements, since those at command sufficed for their combinations, but they continually hoped to make them more perfect. It may be said that all Grecian architects up to Ictinus labored to design the entasis of the columns of the Parthenon.

The oldest columns being really conical, they doubtless observed that the two inclined straight lines appeared by an optical illusion to produce a double concave outline. This outline was then slightly curved, just enough for this right line not to offend a delicate eye.

The order of the Temple of Pietas has no base. Similar are all of the most ancient colonnades, a base being inconvenient. When the Greeks employed bases as useful for the footing of the column, these were at first made circular, only later appearing the custom of placing them on a square plinth. This plinth is a transition between the straight lines of the steps and the column, and has an evident architectural beauty, but when the colonnade is used for passage, its angles are obstructive and are gradually removed by accidents.

The cornice here ends in a cyma, in the form of a cavetto above the facia, which is a departure from traditional principles. It is not a part of the cornice but an element of the covering, so that when the materials differ, the material of the covering is that of the cyma; for example, the facia may be stone and cyma of terra cotta (Fig. 234).

I shall later speak of the composition of each part of the order.

At present, I have desired to show all that is common in this unvarying conception, whether the character of the architecture be rich or poor, severe or elegant.

This is the antique order in its entirety, so complete and with the masterly beauty of truth. Its place in design is the greatest of all by the great instruction resulting therefrom, as well as historically by excellence in architecture. You cannot study it too much, not because you may have to make a colonnade, but because in studying it, you study yourselves.

Yet this order must lend itself to numerous needs, for however simple is the architecture of a civilization, it has greatly varied applications. Certainly, the antique adapts itself by its variety to very different expressions; hence the three great families of orders, Doric, Ionic and Corinthian.

These names correspond to ethnic origins more or less justified, but for us they arouse impressions of earnest strength, graceful elegance, and of rich majesty. Then in each family are infinite varieties, also sometimes borrowings from each other. But finally all these belong to the three types to be studied, Doric, Ionic and Corinthian.

But after what has been said of the proportions and of their infinite gradations, I decline to make a canon of obligatory modules. Only one thing may be said; in each case, each programme, each expression of character, observe the most beautiful examples, and be inspired by them. I shall later present the most celebrated examples with their variety. You can derive from them your inspiration in full liberty of choice.

## CHAPTER III. DORIC ORDER.

SUMMARY. -- Grecian Doric order, its character. -- Frieze is without function. -- Imitation of wooden architecture. -- Column. -- Capital. -- Architrave. -- Frieze; triglyphs and metopes. -- Hypothesis of origin of Doric frieze and cornice. -- Successive constructions of the entablature. -- Transition from wood to stone.

The Doric order is particularly the Grecian order, most magisterial and most perfect in style. It requires precise and thorough study. Yet the Grecian Doric order, properly so-called, I hope at least will not be employed by you, for less than any other does it lend itself to reproduction, even its perfection making imitations grotesque. But as students, nothing better than the Doric order can show you to what degree the perfection of the study of architecture may be carried.

Yet this Doric order, possessing universal admiration and elevated by admiring superstition above all criticism, I shall dare to show that it is defective in one respect, and that its perfect architectural logic sins in one point, that in the Grecian Doric order as seen constructed at Egina or on the Parthenon (Fig. 235), the magnificent frieze, a predominant element comtrolling the arrangement, has of itself no reason for existence. Not a Grecian phenomenon.

First to prove such a bold blasphemy. For that, observe the section of the Parthenon, the plaster cast in the court of the School. The column is admirable in all respects and also the architrave; certainly elements identical with their function in all points. After the three blocks of the architrave are set, the wall is reconstituted and only requires the covering of the portico by ceiling and roof -- the projection of the cornice.

Yet a second course as also set before any element of the ceiling appears, which is the frieze. The ceiling and cornice might rest directly on the architrave without it; the frieze being useless. The composition of the order of caryatids, of the Pandroseum would again suffice here.

What if a thing be useless, if it is beautiful or very beautiful? Thwe word useless so contradicts all Grecian architecture, that here is a fact requiring explanation. This

explanation is very natural, being the traditional imitation of wooden architecture. By a singular and rather disconcerting phenomenon, the most monumental element of stone architecture, the Doric entablature, is an imitation of wood, though this is contested. M. Leseur in particular has sought the origin of the Doric entablature in the imitation of Egyptian art. On the contrary, others have constructed a derivation of this architecture from the hut with its trunks of trees. Leave these archaeological essays, as for me a proof of the imitation of wood in the Doric entablature is the uselessness of the frieze in the stone construction of the Parthenon. This imitation is indeed quite visible; look for yourselves!

Why that imitation? Naturally because the spirit of religious edifices is to traditionally retain the forms and appearance consecrated by veneration. The first temples were ceiled and covered by woodwork, but fires were numerous. The rule was then established to no longer use combustible materials but the forms were consecrated and respected.

I have frequently said that I do not teach archaeology. But one must choose; accept the antique Doric order without examination as a starting point, or seek to understand its sense and composition.

One fact dominates all else in the evolution of architecture; the Doric is the prototype of the antique orders, and during all transformations, this is the most persistent element of architecture; it is then necessary to know either the beginning point of this permanent element, or the law of formation of its primary ancestor, the Grecian Doric order.

Perhaps we may define it as follows:--

The Grecian Doric order is an architectural element with a composition remaining that of a work in wood, but whose proportions are governed by the conditions of truth and necessity resulting from the use of stone substituted for wood. This subject will be more fully explained later, when I treat entablatures, and particularly the frieze.

I shall at once say that this nonsense has not endured. The antique order understood how to realize the absolute accord of purpose and form in compositions, less sublime in style, freed from a restraining tradition, or rather later kne how to find logical arrangements demanded by the use of stone.

When I treat ceilings this evolution will be shown.

It may be added as truly marvelous to have made that borrowing from wooden construction the most monumental expression ever realized in stone or marble.

The Doric column is without base, diminished upwards but not absolutely conical, for its shaft has a slightly curved entasis. It has twenty shallow flutes. Its construction is by drums with very fine joints, in courses as high as possible.

The capital surmounting it is composed of some very small annular fillets above the flutes, of an accented echinus, crowned by an abacus, and without mouldings or recesses.

It is impossible to imagine an entirety better expressing firmness of the support. Whatever its proportions, stumpy as at Peastum (Fig. 236), or slender as at Pompeii (Fig. 237), the vertical fluting clearly indicates the function of the sha By its masculine simplicity, the capital strongly accents its function of a support for the entablature, and the nudity of the abacus even increases this character of strength. In that magnificent work of architecture are very few elements, but such is their truth and harmony, that no person can with propriety omit or add a single thing.

Thus it is in perfect and should be so; the character of Grecian art.

The architrave is as admirable in its simplicity as lintel; a stone extending from one column to another is required. It is smooth on bottom and sides, slightly inclined, ending in a simple fillet; nothing more is needed.

I come to the frieze, which is most characteristic in Doric architecture.

You know its arrangement with triglyphs separated by metopes Like the column, the triglyph has the character of a support, accented also by its channels; the metope is a simple filling often decorated by sculptures or paintings, the whole bearing a cornice.

This is the place to explain the origin of the Doric entablature, as it appears from studying the scientific essays to which it gave occasion, while remaining an architect, which is the best means of reasoning sanely in architecture.

Here the imitation of wood seems demonstrated, and that has been frequently said before. But the current explanation, repeated in all the commentaries, is that the triglyphs recall

the ends of the ceiling beams. This explanation is found in Hittorf and in Reynaud, and has always shocked me(Fig. 238). How to indicate the ends of beams, that do not exist, and at a level below that of the ceiling? If the construction of wooden entablatures had comprised beams at the level later occupied by the triglyphs, be assured that the construction of stone entablatures would have retained its beams at the same level, for nothing would be easier. On the contrary, stone ceilings higher than the triglyphs can be nothing but the faithful representations of an earlier arrangement, that also placed the wooden ceilings at the same higher level.

Then studying this question as an architect, I reach a hypothesis more closely approximating the reality.

To understand the frieze of the Doric order, omit the column and return to the wall. When the architrave is once set, the wall is reconstituted. This is then a course in stone, whether an architrave borne by columns or the last course of a solid wall.

Now by a bit of easy pedantry, question Euripides. He advises Orestes by Pylades to enter the Temple of Diana by passing between the triglyphs to carry off the statue of the goddess, and then Orestes states that he escaped in the same way. Another person suspends a bleeding head between the triglyphs.

When thieves enter a temple to steal, they do not make a difficult climb to merely find themselves in an entirely open portico. Consequently the openings or metopes through which Orestes could pass were made in the wall of the temple itself, which evidently had no lateral porticos. Then these metopes were simply windows lighting the temple, for to not offend certain theories, the temple must have been lighted.

This was plainly the origin of the triglyphs and metopes.

The triglyph is a mullion, or if you prefer, a post, the metope being an opening, and when the entablature closes, no longer the temple itself but a portico, lighting by the metopes no longer having a reason, this opening was closed, not by solid masonry, but by a slab set on edge, an actual plank of marble or stone, decorated like a closed shutter or panel.

And naturally the openings between mullions through which Orestes passed being beneath the ceiling, the triglyphs and metopes were also beneath the ceiling.

Then and always the construction directs us, but it is nece ary to ascend a step to find it.

If such be indeed the primary arrangement of the Doric temple -- and it appears demonstrated -- the formation of the Doric entablature is easily reconstructed, always on condition of remaining an architect. Let us then restore the templ of Euripides.

The architect has erected a wall; the masonry being completed, he passes to wood, which furnishes the upper part of the edifice, the windows and carpentry. It is a small half timber work raised on a wall.

We place a low sill to receive the posts, and prevent its displacement by fixing it on the wall by anchors. Now the low sill is the taenia, covering the architrave; the anchors are the small fillets above the drops, which are nails or pins. On the wall are cut gains A (Fig. 239), which receive the transverse planks pinned to the plate, preventing its dis placement. Note that the drops recall the ancient pins, that in certain entablatures they were attached later and were of marble, while the architrave is of stone.

The architect then set the low sill, that made a regular platform of wood over the entire wall (Fig. 240). At suitable small intervals, he set the posts of his little half timber work (Fig. 241). These are triglyphs and between the posts are openings. Necessarily an angle post, hence an angle triglyph, which has caused many essays.

Then on these posts, a high plate received the rafters; because of the slope the wood is beveled and shows little heigh at the outside, the plain straight band extends above the returns of each triglyph. This sill is higher inside and could receive the ceiling by means of a projection or hollow.

Finally, it supports the rafters, set closer than the posts these are the mutules with double the number of triglyphs, a and these rafters themselves receive the inclined sheathing of the roof pinned on them; hence the facia and drops beneath the mutules. Then as covering are tiles with cover tiles, with an antefixa in terra cotte at the lower end of each cover til . This perspective will make this hypothesis clear. (Fig. 242).

I do not know if I err, but all this appears clear and arch

itectural to me.

This is the origin of Doric. It is probable that during two centuries, these variations were practised with more or less art; doubtless this half timber work had something elegant and decorative; perhaps certain openings were closed by panels or shutters ornamented by paintings, the origin of sculptured metopes.

Then according to the progress of the art of building and after numerous fires, wood was abandoned, and architects were required to make of stone not only the external walls of temples, but even ceilings, framework and roofs. Thus at the Parthenon and in other Doric temples, as well as the Propyleum, we see in marble not only the entablature, but the beams and soffits, as well as all the compartments of ceiling, purlins, tiles and cover tiles. The prohibition of wood is evident.

And that brings again a new digression. I wish to show architecturally a Doric temple like the Parthenon. That is not mere historical curiosity; the Doric temple was the starting point of all antique architecture from which proceeds modern architecture; now a conscious art must know its origins; all that is connected and explains itself, and therefore one knows how to outline for himself his own studies.

Let us extend the scope of our subject and study the Doric temple with reference to the Doric order alone.

## CHAPTER IV. DORIC TEMPLE AND DORIC ARCHITECTURE.

SUMMARY. -- Complementary demonstration of the imitation of wood. -- Parthenon. -- Exclusion of wood. -- Hypethral temples. -- Truss unknown. -- The Doric at Rome. -- Study of the Doric; the triglyph. -- Angle column. -- Inclinations and curves.

In the Doric entablature, it was scarcely necessary to prov the analogy of stone to the use of wood, as explained to you, but I insist on it.

Take the Parthenon for comparison; there the architrave is inclined while the frieze is vertical, because the architrave is the last course of the wall, and this wall must be inclined, like almost all ancient walls.

The triglyph is vertical, as a post should be; there is an angle triglyph, as there must necessarily be an angle post in half timber work. For section, the triglyph has a square horizontal section, but does not have the entire thickness of the frieze.

As for the particular arrangement of the drops, no plausible explanation occurs, except assuming a tradition of transverse planks and the sill of the half timber work.

The metopes are merely a slab set in grooves, so carefully that the English could remove them only by breaking the edges of the triglyph, which held them in a groove; evidently a tradition of the open metopes.

Above the triglyphs extends a band without returns, in which I find the tradition of the plate; the mutules evidently recall the rafters, and their drops are the nails or pins for fastening the sheathing of the roof.

In the facia itself I see the tradition of a plank nailed before the ends of the rafters, whose mutules by their low height indicate the lower part; the final crow-beak moulding itself is nothing but the sheathing of the roof beneath the cover tiles and antefixas.

Note further that in the cornice is marked the slope of the rafters.

The Doric ceiling is raised above the frieze, a position only justified by the tradition mentioned, and which makes this ceiling a restricted and mean composition for lack of height, always by imitation of a wooden ceiling framed into

the plate.

Then give these timbers the proportions necessary for stone and you have the entablature of the Parthenon.

But I have said that even the framework should be in stone. This appears certain, for if wood were rejected for the entablatures and also the ceilings themselves, would combustible parts be retained? Paccard, in his restoration of the Parthenon, fully proves, that it had no trusses, but he assumes wooden purlims and rafters. I have difficulty in believing that a wooden framework ever supported these heavy roofs in marble, a framework so delicate, that the least shrinkage would have dislocated it. This is the weak side of this restoration. The framework comprised only the purlins and ridge beams, and must have been of marble like the ceilings, whose spans were the same. And I demonstrate anew this truth, incontestable in my opinion.

It is impossible to understand the architecture of a given Doric temple, unless one sees the origin of this starting point, the absolute desire never to use wood.

Then how could an architect build a grand and complicated edifice with stone alone, and without employing arches and vaults?

By requiring from stone (or marble) the greatest possible spans, designing his plan in a fashion to permit these spans, and leaving uncovered whatever exceeded the possible span of stone.

The last requirement was not without inconveniences, but the existence of the hypethral temple cannot be denied. Vitruvius says:-- "The hypethral temple is otherwise similar to the dipteral temple (surrounded by porticos), but in the interior it presents columns in two tiers in height, at a distance from the walls for a passage, like the portico of the peristyle; the middle is under the sky and without covering." He adds that no example was at Rome, but was at Athens.

Besides, without forcing the texts otherwise, it is impossible for the hall of the Parthenon to have been in complete obscurity, or that the Minerva of Phidias was hidden in a cave; whatever may be said, temples were lighted, and it is no certain that the doorway alone inside a double colonnade could ensure that lighting. We have just seen that the small

ancient temples were lighted by the metopes; we see on the Acropolis at two steps from the Parthenon, that the Erechtheu had windows as its arrangement permitted. At the Parthenon, on the contrary, no opening permitted lighting, unless this was the open skylight of the hypethral temple.

All this has been frequently said, but I add this remark, that for the temple to be incombustible, the hypethral was required; this was a condition of the construction without wood, an inevitable result of the evolution starting from the temple of wood and ending in the temple of stone or of marble Perhaps there had previously been hypethral temples, and I believe this the more, since the truss does not seem to have been known to Grecian architects, restricted in their carpentry to purlins and ridge beams. Thus it was a necessity for architecture entirely in stone.

I seem to risk a paradox in assuming that the wooden truss, the pivot of all our modern carpentry, was unknown to the Greeks. I know that very numerous restorations of ancient temples indicate it, but this is a modern conjecture, in my opinion. Without delaying in details, I find an essentially Grecian proof of the absence of trusses even in the composition of several existing monuments. The Greeks only made plans for what was required by their construction, no less and no more; every element of their plans is indispensable to the construction for supporting something not otherwise supported. Now we see in these plans many points of support without any reason for existence, if wooden trusses covered the plan.

And this is well demonstrated by the plan of the Parthenon, that I take from the restoration of Paccard, but trace it differently above the architraves, where the walls are reconstitited (Fig. 243). This very skilful arrangement of the plan of the ground story, that produces such beautiful monumental effects, thus transformed into the plan of the upper work, is it not marked by the final evidence of the systematic intention to not exceed the possible spans of the beams, and also for the marble purlins or ridge beams, those superb lintels, still in place with 19.7 ft. spans at the Propyleum? With this plan, all the spans in the work are less than 19.7 ft. those of the treasury alone approaching that measure.

There is one monument that demonstrates it well, the double portico called the Basilica of Paestum (Fig. 244). Here were perhaps not the same reasons causing the rejection of wood for the temples; in any case, why did Grecian architects, for whom the useless did not exist, encumber the middle of a portico by a row of columns, if these columns had no necessary function in construction? Merely the ridge required the construction; not knowing how to artificially support it in the air, they supported it from the ground, absolutely as in the ancient Swiss chalets (Fig. 245), such interesting types of primitive construction in wood, where are always timbers in the axis beneath the ridge, an actual ridge partition, with no reason for existence of the truss.

To show you fully the Grecian Doric order, it is necessary for you to see its origin, and also this entire architectural evolution; wooden architecture first employed for the upper parts of temples, then probably abandoned after frequent fires, stone replacing wood; but the traditions and forms of wooden architecture being consecrated by veneration and retai ed by architects, perhaps by fear of the hemlock. Then by a prodigy of taste, harmony and style, this imitation of wood with the proportions necessary for stone became the noblest element of the monumental architecture, which was to control the art of all antiquity and also modern art.

Such is the Doric order. Its proportions vary more than in the other orders. The column does not have 4 diameters in height at Corinth (Fig. 246), but more than 8 1/2 at Cori (Fi 50). The margin for design is vast, but you will only study with real benefit this profoundly motived architecture, if yo know its origin and formation. This caused me to emphasize the topic.

It is frequently said, Grecian Doric and Roman Doric. But if by inadvertence I speak of Roman art, this is a brief way for expressing Grecian art as practised at Rome. There were no Roman architects, at least for a long time; but between the Parthenon and the Theatre of Marcellus are centuries, that are always manifest.

At Rome is first found the Doric of the Tabularium (Fig. 247), very similar to the Doric of Greece; then the Theatre of Marcellus (Fig. 45), that of the Colosseum and some others.

The three orders mentioned have engaged columns. As an orde of pilasters, I can mention the tomb of Bibulus.

Little by little, the Doric order loses its severity, and its originality. The capital no longer has its strength, its abacus is moulded, and an astragal separates the shaft from the capital; the column itself no longer expands into a monumental support. The flutes vanish or are modified, and the base appears. The mutules become horizontal, and the architecture detracts from its character as a lintel. Construction is itself lost to view.

But the architecture is less majestic and more easy, and in the monuments of Rome of the emperors, the Renaissance found the types of the Doric order in which, more than in the others, its genius appeared with Bramante, Peruzzi, Sangallo, Ligorio, Philibert Delorme, Jean Bullant, etc.

This I had to say of the Doric; it is nothing, if you expect from me a Bareme or a Vignola, recipes for proportions or of modules. I do not adhere to them -- and there are none. There are averages, very differebt from absolute rules, and especially are beautiful examples. Between Paestum, the Parthenon, Cori, Pompeii and Marcellus in antiquity; Palace Massimi (Figs. 248, 249), Palace Farnese, Ecouen, the Louvre, S. Sulpice and Palace of Justice in modern times (Fig. 39), you have the choice of admirable types; know how to select accodding to the character of the edifice and the requirements of your construction. All is in that.

I do not wish to leave this subject without showing you the true key to the study of the Doric orders as well as their difficulty. With some exceptions, the Doric order is characterized by its triglyphs, which have finally become but an ornament on the friexe, though a capital and inflexible ornament. By its regular spacing, the triglyph is for a Doric composition just as beating time is to a musical composition; it distance between axes must be an aliquot part of that between the axes of the columns, and in returns, whether the angles are convex or reentrant, or in extended architecture, the design must always be controlled by the possible arrangement of the triglyphs.

Thus at the Propyleum of Athens, (Fig. 250), the middle intercolumniation having to be of exceptional width, being the

central passage, this excess of width cannot be arbitrary, for the number of triglyphs determines it; while the other columns are distant by twice the distance between axes of triglyphs, the former has thrice this; there is here a numerical law of proportion, not imposed on any order other than the Doric.

But particularly with regard to the angle columns is apparent the result of the triglyph.

In all colonnades of the Grecian Doric order, temples or propyleums, the anglw column is a little larger than the others (about 1/40), and it is sensibly closer. This irregularity has a fine effect, giving to the angle of the edifice the strength always necessary for the appearance; observe how this strength is lacking where this difference in the intercolumniations does not exist or is too small, for example at th Madeleine, where the angle column viewed obliquely and agains the air appears isolated and thin for its function.

This magnificent artistic result obtained by Doric architecture is not an esthetic conception created by it; for were this so, the architects almost at the same time as the Parthenon, who composed the Ionic temples of the Acropolis would have obeyed the same principle of appearance, and later it would be found in Corinthian temples; if the angle intercolumniation there be a little less, it is scarcely sensible, while this difference is so clearly expressed in the Doric.

This is because in the Doric, it is a mathematical result of the arrangement of the triglyphs. It is the last term of a syllogism, whose premises are the wooden corner post, then the angle triglyph of stone. The triglyph being at the angle and narrower than the column, cannot have the same axis as this; the regularity being above in the frieze, the intercolumniation cannot be regular. The entire explanation of the angle intercolumniation is this (Fig. 251).

I must finally mention this peculiarity of Doric architecture, the inclination of all its elements. Neither verticals nor horizontals are found; horizontal surfaces are curved, and vertical surfaces are inclined in the sense of the pyramid. Thus the steps are higher in the middle than at the ends the line of the capitals and architraves is curved, the entablature is curved in height and not in plan. These refinements

with prodigious precision escape the eye, but certainly avail much in the impression produced by the monument. To obtain an idea of this, consult Penrose's book on the Parthenon, and you will be amazed.

Yet this refinement must have a reason for its existence, and this is always the pursuit of absolute perfection. Assume a perfectly vertical wall behind the portico and a much diminished column also perfectly vertical; the space between wil be sensibly larger at top than at bottom, contrary to the instinctive logic of the observer; hence a bad effect as in Fig 252, where the column is represented at one side with vertical axis, while at the other it is shown with inclined axis, whose inclination is slightly exaggerated for the demonstration. Assume on the other hand an entablature perfectly horizontal; under the height of the pediment, that increases fro ends to middle, it seems to bend downward at its centre; again a bad effect. The Greeks never condemned a bad effect, but always fought it to victory. To obviate these imperfections, they did not fear to engage in a formidable struggle with unexpected difficulties. In our days, if the Parthenon were to be identically built again, even if everything necessary were at command, such as money, materials and time, it would not succeed. Also anywhere in the most perfect things, measurement gives differences; for example, one admires the execution of a colonnade where diameters do not vary one per cent; on the Parthenon, they do not vary one per thousand, indeed do not vary at all.

That is what were those artists and their art.

Let us admire those monuments as they have remained to us (Fig. 253), but know how to respect them enough to forbid us to pretend to build them again.

# CHAPTER V. THE IONIC ORDER.

SUMMARY. -- Origin. -- Simple Ionic. -- Decorated Ionic. -- Base, shaft and capital. -- Angle volute. -- Entablature. -- Ceilings of porticos.

I spare you the symbolism, that sees man in the Doric, woman in the Ionic, finds in the base the shoes of the young girl, in the flutes the folds of her robe, and in the volutes of the capital the bands of her headdress.

Between the Doric and Ionic orders at the origins were evidently ethnic differences; perhaps the Doric proceeds rather from Egyptian and the Ionic from Asian. But especially is it the fact, that everywhere and always are different aspiration of mind and taste; if the Doric order be incomparable in expressing strength and majesty of construction, proud of itsel the Ionic seems created to express grace and refined elegance

Did the Ionic order, like the Doric, originate in wooden architecture? Perhaps, since some of its frequent elements suggest that origin, such as the dentils, the evident trace of close joints, so clearly shown in the Lycian tombs. The volutes themselves indeed might be the tradition of a capital at first composed of a wooden shaft and two kinds of round brackets. But these are only hypotheses, and it is best to say that nothing is known.

The Ionic orders, outside of archaeological classifications may be divided into two classes, even in antiquity, the simple and the decorated Ionic. At Athens are found the most instructive examples.

I term simple Ionic that of the Temple of Nike Apteros (Fig 254) and of the Propyleum (Fig. 255); decorated Ionic is that of the Temples of Erechtheum and of Minerva Polias (Fig. 256) This difference is particularly manifested in the capitals. In the former, the shaft is terminated by an astragal and directly receives the echinus of the capital, the plan reproduced in Fig. 257 being nothing more than the outline of the joint between the shaft and capital. In the latter, between the fluted shaft and the capital is an intermediate space, a band richly decorated by palmatiums, whose function is quite undecided. Besides, all mouldings are much more ornamented, the bases themselves being sculptured.

Preference may be given to one or the other; what I wish t indicate is, that in the Ionic order also are expressions ve different from the simplicity of the order of the proportion up to the extreme richness of its neighbors.

The Ionic column always has a purely circular base; the pr files are greatly varied, but it may be said that the more ancient the edifice, the more the base bears the character o a footing. There is an ingenious explanation of the arrangement of the base, that conforms to the more ancient examples the column, or rather the shaft, is terminated by two astragals at top and bottom (Fig. 258); consequently the fillet a lower torus form a part of the shaft, the base being only th plinth, plain or decorated, which receives this torus; the base or lower astragal of Cori appears to confirm this hypot esis.

The bases are further much varied and frequently very complicated. The simplest and purest are those of Athenian architecture, such as those of the Temples of Erechtheus and of Minerva Polias, or that of the Propyleum, that you have also just seen. Others greatly enlarge the bearing of thecolumn, such are especially those of the internal columns of the Temple of Bassae (Fig. 159); finally, there are some ver much decorated, either by the quantity of mouldings, for exa ple on the Temple of Minerva at Priene (Fig. 260), or by qui illogical horizontal flutes, by which it is necessary to recognize that proximity to the ground, like the bases of the Temple of Samos (Fig. 261), or finally by sculptures on the lower part of the shaft, like the fragment from the Artemesion at Ephesus (Fig. 262), which is also rather a part of th column than a base.

Since some love classifications greatly, the Ionic order has also been subdivided, and you will sometimes be treated as belated ignoramuses, if you confound the Ionic with the Attic base; but the truth is that in Greek art is great variety, and the classifiers might amuse themselves far more, if we could see all that has disappeared.

However this may be, the Ionic base of the best epochs do present those concave profiles, that contradict even the purpose of a base.

The shaft is much less diminished and is thinner than in

the Doric order, and it has 24 deeper flutes separated by fi

The capital presents the very strong composition known to you; above the echinus the abacus curves in volutes, except the upper reverse ogee, that forms the bed for the architrave The volutes have great impobtance in Grecian Ionic, but later diminish in size.

This almost gives to the Ionic column an individual character; but there are two principal faces and two lateral sides; a small capital (Fig. 265) preserved in the Museum of Athens is extremely simple and demonstrates this well. This particular composition of the Ionic capital is even the cause of serious difficulties in design for the returns. When the portico forms an angle, desiring all the capitals of the sides to show their faces, Grecian architects conceived the angle volute, convex on the exterior, concave in the interior. This was a necessity, but must be regarded as only an expedient.

When there was only a small number of columns, like the fou columns of an atrium, it would have been almost impossible to employ the ordinary Ionic capital with principal and lateral faces. This then led to the caoital with four angle volutes and perfectly regular, of which we have so many pretty examples at Pompeii(Fig. 264).

The entablature is here composed of the architrave, of a frieze, either plain or decorated by sculptures, and a cornice consisting almost entirely of the facia.

The architrave no longer has the unity of the Doric arbhitrave; it presents slight offsets dividing it into three part slightly projecting beyond each other. Perhaps this may be a tradition of a covering of boards; Then a moulding crowns it, generally a reverse ogee and fillet.

When the frieze is not plain, it is decorated by sculptures in relief. That of the Erechtheum (Fig. 265) exhibits a special arrangement. It is of nearly black stone, and set in it are figures in relief carved in white marble, perhaps painted.

On the edifices of Athens, the cornice comprises a geison strongly hollowed out beneath; below are delicate mouldings cut in the undercutting of the geison, at the top being a crow-beak moulding, already mentioned.

In some Grecian monuments, as at Olympia, Priene in Asia

Minor (Fig. 266), as well as on the Pandroseum at Athens, the profile of the lower members of the cornice is more important and is especially characterized by the dentils.

As for the agreement of the entablature with the internal construction, it is irreproachable. Beams of monumental section rest on the architraves, these occupying the height of the frieze, and supporting the coffers of the ceiling, corresponding to the height of the cornice. The ceilings of the Propyleum (Fig. 267) are sufficiently preserved to show well this beautiful arrangement, same as those of the Temple of Erechtheus. You will see all that better in the books or in the plaster casts of the galleries. I can only comment briefly on what you should read with care.

Further, I have not much to say of the Ionic order in Roman antiquity nor since the Renaissance. With some variations, it is always the Ionic order, and if taste may vary infinitely, theory never changes.

## CHAPTER VI. THE CORINTHIAN ORDER.

SUMMARY. -- Its character. -- Capital. -- Varied example -- Entablature. -- Modillions. -- Monumental Corinthian. -- Caprice and elegance. -- Shafts, their design. -- Varieties called the Composite order.

The Corinthian order was at first exceptional and reserved for little structures in ancient Greece, but became the most employed and most monumental in the Roman epoch. Doubtless its ornamental richness, its easily theatrical appearance, responded better to the state of society under the rule of the Roman emperors. I said at the beginning of this course, that the grand architect of an epoch is its social and moral state. In applying this truth to the antique orders, I frankly state, that the Doric is the republican order, and the Corinthian is the imperial order.

Yet it is interesting to see it at its origin in the architecture of Greece. The best known example is the Choragic Monument of Lysicrates (Figs. 268, 269). Excepting the capital, it may be said to be entirely an Ionic order.

As for the capital, its arrangement is always nearly the same; the shaft terminates with an astragal, above which the capital essentially comprises a bell, a surface of revolution analagous to the echinus of the Doric and Ionic capitals but higher, and an abacus here no longer square, but limited by four concave arcs of circles, inscribed in a square. To the bell is attached a row of large leaves to the number of eight in the principal and diagonal axes, against which rest eight other and smaller leaves on the intermediate axes, all springing from the astragal. The most typical is perhaps that od the Tholos of Epidauros, where the foliage allows the curve of the bell to be seen through its openings (Fig. 270).

Between the great leaves spring eight scrolled stems supporting the four corner volutes, that sustain the great projection of the abacus, as well as middle volutes, that are purely ornamental.

I shall not describe in detail these capitals, but observe beautiful examples; I limit myself to show you its general composition by a trace of the plan (Fig 271), taken from the Temple of Mars the Avenger, mentioned before (Figs. 4, 5).

It is indispensable to well understand this plan in order t correctly draw a Corinthian capital. But remember that without exception all those remaining to us from antiquity are in marble, which permits refinements -- sometimes abused -- that stone cannot allow. Yet a too servile imitation of the antiqu has frequently caused models to be sought in capitals of marble. There is a danger to be noted. The most ancient are also the most robust; thus those from Assizi (Fig. 272), Tivoli (Fig. 273), from Palestrina and from the temple of Vesta at Rome, have a sculpture much more resistant, than those of the imperial epoch at the Pantheon, the Temple of Antonine and Faustina, etc. Yet among the most beautiful must be cited that of the Temple of Jupiter Stator, a cast of which you have at the School of Fine Arts. *

The richness characterizing the capital continues in general in the entablature. The architectural projections are separated by mouldings generally sculptured; the friezes are covered by rich sculptures, as on the Temple of Vesta at Tivoli (Fig. 273), or on that of Antonine and Faustina, which you have seen before (Fig. 52). Also there are simpler ones, such as the Temple of Minerva at Assizi, that of the Pantheon at Rome, or finally that of the Temple of Jupiter Stator (Fig 276), where the richness is concentrated in the architrave and the cornice.

The noblest and grandest in appearance is that of Mars the Avenger; unfortunately only its beautiful architrave remaibs from the entablature.

In Corinthian cornices, you find all the elements of the antique mouldings, the reversed ogee with its heart-leaves, the quarter round with its eggs, the bead with its pearls,

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* Note. In designing antique monuments, I always employ their classical names. This is the only means of being understood. For example, I am aware that volumes have been written to discuss whether the Temple of "Jupiter Stator" should be called Temple of "Castor and Pollux" or "Graecostasis", etc. As always, far from giving light, these discussions have produced obscurity. But since the Renaissance has always said "Jupiter Stator", -- I do not know why -- ; so is this beautiful monument named in a multitude of art books; only by continuing to give it this name may one know of what I speak.

the cyma with its palmatiums or foliage. What further characterizes most of its cornices is the modillion, a kind of small console supporting the cornice. You have laready seen examples, notably with the cornice of the Temple of Concord (Fig. 13). One of the most beautiful examples of cornices so treated is that of the magnificent portico of the Temple of Jupiter Stator previously given (Fig. 274), and of which I have mentioned a complete cast in the glazed court of theEcole. Sometimes the modillion is recessed far beneath the cornice, as in the colossal entablature of the Temple of the Sun or Portico of Nero at Rome.

It is further necessary to recognize, that on all these entablatures the modillion is an apparent souvenir of an actual console, but is nothing more than a motive of sculpture or ornament, and plays no structural part; long afterwards on the cornice of Palace Strozzi do we again find the modillion an organ of construction, perhaps because the Florentines did not have colossal stones at command. The drawing shows to you, after a very interesting study of M. Pascal, better than all I could say, what is the proper function of the modillion

The variations of the antique Corinthian orders are infinite, and I cannot show all; there are few subjects for which data are more abundant.

The antique Corinthian order is also that which most employed the different marbles. That character cannot be passed over in silence. On the exterior are some monolithic shafts of colossal size, those of the Temple of Antonine and Faustina being of green cipolline marble, those of the colonnade of the Pantheon and of the Temple, that must have existed at the back of the Forum, were of granite. The internal columns of granite and of marble were in prodigious numbers in the Ba basilicas and palaces. A very interesting example of this colored architecture, although it suffered even in antiquity and also since from unfortunate restorations, is the interior of the Pantheon of Rome(Fig. 277); I regret my inability to show its coloring.

But the Corinthian order, that is particularly the one of colossal pompous and theatrical arrangements, is also that lending itself most to delicate caprices. The Italian Renaissance especially left in that order of ideas the most ex-

quisite examples. And particularly in the capital has taste been allowed a free course. It suffices to recall the names of Alberti, Bramante, Baccio Pintelli and Ligorio. I limit myself to mentioning some examples, notably the masterly design of the church at Rimini by Leo Alberti (Figs. 278, 279 then the portico of the Church at Spoleto (Fig. 280), the pilasters of Palace Cancellaria at Rome by Bramante, the tombs in S. Maria del Popolo at Rome, the Monument of Colleone at Venice, and the ground and second stories of the Municipal Palace at Brescia (Fig. 281). I could extend these mentions to infinity.

These great artists have taught us by their words, that the forms of monumental architecture must be more flexible and free in programmes of elegance and fancy.

It is the same with the shafts. In grand architecture, the shaft is regularly fluted, except in colored marble or granite. And it is necessary to remark, that for these great orders granite is in more common use than marble, and that when marble is used, it is generally colored in a uniform ton If light in color, like antique yellow, it is fluted. In the capricious orders variegated marbles are more acceptable, or indeed the fluting is but partial, a part of the shaft being sculptured. Examples are innumerable. In a word, unity is necessary to grand architecture, and the little, calls for variety. The Temple of Mars the Avenger or the Madeleine would be ridiculous if reduced, and the little gallery at the entrance to the chapel of the School would be absurd, if enlarg

As for modern Corinthian orders, I have already shown a great number, naturally selecting the best, which will suffic

Finally, in what is termed the Composite order, you should see only a variant of the Corinthian. This name is nothing more than a claim of some authors, who found the word easier than the thing. There are very beautiful examples, but certainly the orders of the court of the Louvre are indeed Corinthian orders. A volute larger or smaller in a capital does not suffice to change the class of an architectural order.

## CHAPTER VII. THE TUSCAN ORDER.

SUMMARY. -- Character. -- Stone columns, wooden entablatures. -- Researches of M. Leseur. -- Delicacy and air resulting from this mode of construction. -- Projecting roofs. -- Modern Tuscan. -- Erroneous practices. -- Applications.

It will doubtless be surprising, that I only speak of the Tuscan order after treating of Doric, Ionic and Corinthian. All Vignolas indeed begin with Tuscan, and this has become a consecrated custom. But in the Tuscan as presented to us, I cannot recognize a distinct order. What makes the ground story of the Luxemburg (Fig. 282) anything but a Doric order, m more soberly designed than the Doric of the second story? Again, is not the order Doric for the ground story of the cour of fountains at Fontainebleau (Fig. 283)? To be logical, a classification thus discovering the Tuscan and then the Composite, which at a certain time discovered the order of Paestum, should not stop in its course; at least a hundred orders should endow our architecture. I need not state the result of such confusion.

Yet I recognize a Tuscan order. What is it?

On this subject, I borrow much from the course of M. Lesueu who seems to have clearly established the proper character of the Tuscan order, which is the order composed of stone columr and wooden entablature.

M. Lesueur made a very profound study of the antique orders perhaps sometimes rather systematic and too mathematical, anc when he came to rules for application, displayed much sagacit in the criticism of authors; in regard to the Tuscan order, he very fully demonstrated the error of the Renaissance authors, who saw in it only a heavy and degenerate Doric. He showed that the Tuscan order retained its wooden entablature as its characteristic, and that consequently this mode of construction, far from being an element of heaviness, on the contrary presented more slender and widely spaced columns. It is the lightest architecture that we can find in antiquity.

Conjecture would rather be the word, yet there still exist at Pompeii columns of this Tuscan order at the soldiers' cam (Fig. 284) and some others, but their entablatures have disappeared. Alone in Tuscany, the natural heiress of the ancient Tuscans, was evidently continued a tradition, which produced

in the epoch of the Florentine Renaissance exquisite masterpieces of taste and elegance, the purest expression of the Tuscan order.

These entablatures of wood are always characterized by grea projections of the roofs. Visible rafters frequently have decorated ends and ensure this projection. The different combinations employed for that effect may be collected in two groups in one the rafters have no support other than the wall or the architrave taking its place (Fig. 285), and then the rafters must be strong enough to not bend under the weight supported by the overhang, and for this puepose they are often doubled for a part of the projection; in the other the projection is ensured by means of an external purlin borne on the projecting end of the tie-beam of the truss (Fig. 286); this purlin then has the same span between the trusses as the others, and its horizontal position governs the projection of the rafters, which may project a certain distance beyond it.

The first case is that of the Tuscan order. There can be no projection other than that of the rafters beyond the architrave, which is really a sill. A frieze would be without reason, and a cornice still more; the true cornice is the raf ers, just as in the original Doric; thus these exquisite productions of the Rehaissance are found in the first manifestations of Grecian art. Here again is found the same character of truth, nothing but truth.

When you employ this element of architecture, you often indicate it very badly; above the columns is indicated without motive a high entablature; on the contrary, even with very flat roofs, permitted by the tiles employed in Tuscany, the great projection of the rafters almost entirely conceals in elevation the architrave, and would even conceal the tops of the columns, if the inclination were not so small. Then again in this respect the Tuscan order must be expressed by extreme delicacy.

Among the numerous and remarkable productions of such an original art, I shall cite; Palace Poschi and Palace Medici at Pisa; Palace del Comune and Palace Podesta (Fig. 287) at Pistoja; a palace on Via Romana at Siena, as well as the Palace Public of the same city; Palace Guinigi at Lucca and the Villa of the same name; Palace del Comune at San Gimigiano;

that of the Podezza at Arezzo; a palace at Montepulciano; finally at Florence, the Loggias Bigallo (Fig. 288) and Bardi; Palaces Spini, Guigni, Uguccione and Nicoloni. (Consult especially Famin and Grandjean, Edifices de Florence, and Rohault de Fleury, Architecture Toscane).

In general you do not better express the case of the projecting roofs with external purlins. In such cases, we frequently see in your projects consoles placed by chance and fragments of broken purlins. Those so doing thereby show, that th do not in any measure understand the construction, which they wish to make an architectural motive; if the rafters need support other than the wall or the architrave, this support is necessarily a purlin or extended sill, and this purlin can only properly be supported on the tie-beam of the truss prolonged externally; there might be intermediate consoles, but these are quite useless, since the distances between trusses is carefully calculated to permit the span of the purlins, and these would be an incumbrance without motive. As for the merely horizontal console, like the extremity of a tie-beam, but which is merely a piece of timber fixed in the wall, it affords no stability; this could only be the overhanging end of a tie-beam, strong enough to not bend under the weight of the external purlin.

These designs are not so far from us as you might believe. Without mentioning numerous villas inspired by modern Tuscan architecture, you have near Paris a contemporaneous monument of high worth, the Hospital for Insane at Charenton by Gilber There the porticos of the yards are of the Tuscan order, remarkably designed. This example will serve as a conclusion to this study. (Figs. 289, 290).

## CHAPTER VIII. APPLICATIONS OF THE ORDERS.

SUMMARY. -- Classical examples of the orders. -- Comparisons. -- Tables of actual dimensions. -- Tables of proportional dimensions. -- Examination of some monuments.

I certainly do not pretend to have said anything concerning the orders; a volume would not suffice, and if my course lasted six or eight years, I could devote numerous lectures to the study of the orders. But then I should have to enter into detail, analyze proportions, do again what you find everywhere, for there is no subject in architecture that has been more frequently treated. I have sought to say what is not enough found in those too brief books, scarcely more than formularies. I hope to have shown, that the antique orders are logical, that their study should be thoughtful, that one should know how to use them, to know if one be correct, or to deviate therefrom only with knowledge of the risks and dangers.

The orders occupy a great place in your studies; already in speaking of proportions in general, I have shown some indisputable laws of proportion in its necessary varieties. You will have the personal advice of your professors in the study, but always remember in the freest career of the imagination, that above formulas is a theory of the orders, never to be forgotten.

In fact and historically, the study of the orders is the pivot of modern architecture since the 16th century. In the study of walls, cornices, doorways, windows, exteriors and interiors, you will continually refer to it. Hence the subject is of capital importance, and you cannot be too much permeated by principles permitting you to give to the study of the orders the desired proportion, according to the programme received and the character at which you aim.

### Classical Examples of the Orders.

After having shown you the most beautiful examples of the orders, it is necessary to bring them under your eyes. This will afford the proof and confirmation of the principles just studied.

But I do not present them only with a unit diameter, for nothing is more deceptive than this module unit, that conceals the actual size. Thus I produce these examples at the same

actual scale, and you can then best see the profound differences between monumental architecture, and that of small buil ings.

For the Doric order, I do not go back to the two archaic examples of Corinth or Sicily. Very interesting to study in the history of art, they remain outside theoretical studies. At Paestum we find Doric architecture in full possession of itself and already producing a masterpiece.

The colonnade at Paestum is of imposing dimensions, and wit out exaggerations; the architecture has a very great firmness and the most magnificent effect. It is interesting to compare in the same edifice the external order and the small internal order of the cell, a relation existing in reality, for by the destruction of the walls of the cell, the little internal orders find themselves adjacent to the great colonnades (Fig. 291).

With the Parthenon, we reach the climax of Greek art, perfection itself; unfortunately the same comparison cannot be established as at Paestum, the internal order being reduced to conjecture.

Of the same epoch and art is the Propyleum of Athens. There are two Doric orders, the principal one forming the true Propyleum or entrance portico of the Acropolis, the other is smaller and forms the facades of the two wings.

In comparison to this monumental architecture, see the elegant and even slender order of the Temple of Cori. The entablature is extremely low, especially the architrave. The edifice is further remarkable for the delicacy of its proportion themselves.

Finally, the Doric order ot the Triangular Forum of Pompeii is the type of graceful and rather refined architecture, that characterized the Greco- Roman colonies of Magna Grecia.

Then in antiquity were very different types of Doric orders I cannot represent them all graphically, limiting myself to a comparison of the two extremes, the great order of Paestum and that of the Triangular Forum of Pompeii, between the two being that of the Parthenon (Fig. 292). The sight alone of these drawings at the same scale suffices to exhibit their variety. It is also useful to compare the results of some measurements.

For the distances between axes (for normal spaces, neither at the angle nor at the middle), we obtain the following measures.

| | |
|---|---|
| Paestum (great orderl | 14.6 ft. |
| Paestum (internal order) | 11.5 ft. |
| Parthenon (great order) | 14.1 |
| Propyleum (great order) | 11.8 |
| Propyleum (small order) | 7.4 |
| Cori | 7.4 |
| Triangular Forum of Pompeii | 7.3 |

If we now take the spans of the architraves between the abacuses, or the element of fragility of construction, we find.

| | |
|---|---|
| Paestum (great order) hard limestone | 6.2 ft. |
| Paestum (small order) | 5.3 |
| Parthenon, marble | 7.5 |
| Propyleum (great order), marble | 6.4 |
| Propyleum (small order), marble | 4.5 |
| Cori. Hard limestone | 4.7 |
| Pompeii, hard limestone | 5.2 |

The differences between these various measures are sensible but are very far from being in the corresponding proportions. To be certain of this, it suffices to collect in a table the chief actual dimensions of the preceding monuments, then to give the ratio of each to the diameter of the column.

That is the purpose of the two following Tables A ahd B.

(For Tables A and B see page 198.)

These tables best show the freedom of ancient art, not subjected to numerical formulas. Yet not freed from the laws of the material, so that I call your attention to the last colum of Table A. The sole element with little variation is the span of the architrave, the dangerous element of the construction. While the diameter at Paestum is to that at Pompeii about as 3.72 to 1, the span of the architrave is only as 1.18 to 1.

Here intervenes that imperative element of construction, that limits the prudent span of a stone lintel. Thus, while considerable differences are found in the diameters of the columns and their heights, the differences in spans are almost nothing. For stone architraves the differences from the longest are 0.82, 0.92, and 1.41 ft. If a greater span of 9.2 ft. be taken, 1.48 ft. more than that of Paestum, it is that

## TABLE A.

## DORIC ORDER.

| Monuments. | Actual Dimensions. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lower Diameter of Column. | Diam. of base. | Inter-columniation | Height of Column | Height of entab. exc. cyma | Width of abacus | Distance of passage between | | |
| | | | | | | | Columns | Bases | Abacuses |
| Great temple of Paestum External Order | 6.80' | Same | 14.66' | 28.00' | 12.66' | 8.50' | 7.90' | Same | 6.15' |
| The same. Internal Order. | 4.47 | " | 11.48 | 19.82 | " | 6.17 | 7.00 | " | 5.32 |
| Parthenon. | 6.15 | " | 14.10 | 33.20 | 10.75 | 6.62 | 7.96 | " | 7.48 |
| Propyleum. Great Order. | 5.05 | " | 11.55 | 28.80 | 9.94 | 6.45 | 6.81 | " | 6.43 |
| The Same. Small Order. | 3.52 | " | 8.29 | 19.20 | 6.24 | 3.80 | 4.76 | " | 4.48 |
| Temple of Cori | 2.35 | " | 7.37 | 20.30 | 3.18 | 2.66 | 6.03 | " | 4.72 |
| Pompeii. Triangular forum. | 1.82 | " | 7.25 | 13.35 | 3.22 | 2.05 | 6.44 | " | 6.22 |

## TABLE B.

## DORIC ORDERS.

| Monuments. | Ratios. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ratio to Diameter. | | | | Ratio to Height of Column | | |
| | Of Inter-columniation | Of Height of Column | Of Height of Entablature | Of Height of Entire Order. | Of Inter-columniation | Of Entablature | Of Entire Order. |
| Paestum, external order. | 2.17 | 4.29 | 1.87 | 6.16 | 0.51 | 0.44 | 1.44 |
| Paestum. internal order. | 2.57 | 4.44 | " | " | 0.58 | " | " |
| Parthenon. | 2.29 | 5.57 | 1.75 | 7.32 | 0.41 | 0.31 | 1.31 |
| Propyleum. great order. | 2.36 | 5.70 | 1.97 | 7.67 | 0.41 | 0.35 | 1.35 |
| Propyleum, small order. | 2.35 | 5.45 | 1.77 | 7.22 | 0.43 | 0.32 | 1.32 |
| Temple of Cori | 3.14 | 8.64 | 1.35 | 10.00 | 0.36 | 0.16 | 1.16 |
| Pompeii, triangular forum. | 3.99 | 7.33 | 1.77 | 9.09 | 0.55 | 0.24 | 1.24 |

employed at the Parthenon, a monument constructed of marble with a greater resistance.

In reality, if something nearly constant occurs in the design of the Grecian orders, this is not the module of proportions, but is the actual dimension permitted by the construction.

I have particularly mentioned the Doric orders, the starting point of all architecture of the orders. As for the art termed Roman, it scarcely employed the Doric order excepting for engaged columns, which differ entirely from the orders presented at this time.

In the Renaissance, Doric colonnades are not sufficiently numerous to lend themselves to these comparisons, but seek the numerous examples furnished by modern architecture.

It will be easy to compare these examples as already done for antique architecture, and you will not fail to find in that study the confirmation of what I have already taught with regard to proportions.

For the Ionic order, beautiful examples are less numerous. Two tendencies of Ionic architecture in antiquity have been mentioned; simplicity in one, richness in the other -- As very simple orders, that of the Temple of Wingless Victory at Athens, a small and still slightly archaic edifice, is remarkable for the vigor of its proportions, as well as the style of the details.

The Propyleum presents us with an Ionic order in complete perfection. The capital is particularly admirable. But this order is internal and does not have the complete entablature.

With the Temple of Minerva Polias and the Erechtheum we attain to the richly decorated orders with great taste and delicacy, yet not without a certain excess; a little of the Asian spirit may be superposed here on the pure Grecian genius. Then I recall to you the examples of Priene and of Pompeii. These suffice for comparison like those made for the Doric, and are given in Tables C and D. (Page 200).

I do not treat of the conclusions to be deduced from these tables, but limit myself to showing a graphical comparison of the principal examples of the order(Fig. 293).

In modern architecture from the Renaissance to our days, the Ionic order has been least employed as a pure colonnade.

## TABLE C.;

## IONIC ORDERS.;

| Monuments.; | Actual Dimensions.; | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lower Diam. of Column. | Diam. of Base. | Inter-columniation. | Height of Column | Height of Entab. exc. Cyma | Free space between | |
| | | | | | | Columns. | Bases. |
| Temple of Wingless Victory. | 1.71' | 2.39' | 4.62' | 13.33' | 3.80' | 2.92' | 2.24' |
| Propyleum | 3.48' | 4.55 | 11.90 | 33.70 | " | 8.50' | 7.42 |
| Temple of Erechtheum | 2.22 | 3.14 | 6.73 | 21.60 | 3.76 | 4.50 | 3.53 |
| Temple of Minerva Polias | 2.76 | 3.66 | 10.30 | 25.00 | 5.52 | 7.38' | 6.06 |
| Temple of Priene | 4.14 | 5.73 | 11.52 | 38.20' | 9.05 | 7.40 | 5.78' |
| Forum of Pompeii | 2.12 | 2.88 | 7.20 | 20.70 | 3.80 | 6.17 | 4.32 |

## TABLE D.;

## IONIC ORDERS.;

| Monuments.; | Ratios.; | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ratio to Diameter. | | | | Ratio to Height of Column. | | |
| | Of Inter-columniation | Of Height of Column | Of Height of Entab. | Of Height of Order. | Of Inter-columniation | Of Entablature. | Of Entire Order. |
| Wingless Victory | 2.70 | 7.80 | 2.22 | 10.02 | 0.35 | 0.29 | 1.29 |
| Propyleum | 3.43 | 9.65 | " | " | 0.36 | " | " |
| Erechtheum | 3.04 | 9.75 | 2.21 | 11.96 | 0.31 | 0.23 | 1.23 |
| Minerva Polias | 3.68 | 9.09 | 2.00 | 11.09 | 0.41 | 0.22 | 1.22 |
| Priene | 2.80 | 9.31 | 2.20 | 11.51 | 0.30 | 0.24 | 1.24 |
| Forum of Pompeii | 3.40 | 9.78 | 1.80 | 11.57 | 0.35 | 0.18 | 1.18 |

I cite the old court of the School of Medicine, the facade of Church S. Vincent de Paul, and a vestibule of the court of the Louvre, all in Paris.

These Ionic examples differ little in general from the antique orders, except in details; thus their elements are less accented than in the Grecian orders, the volutes of the capitals have lost their breadth, the bases project less, the architraves are lower, and the cornices are less vigorous in profiles.

One might almost say, that since the monuments of the Acropolis and the caprices of Pompeii, the Ionic order has not become acclimated, but has been denatured and almost suppressed by its most recent competitor, the Corinthian order.

Examples of the Corinthian order abound. Not in Greece itself, where that order was born, but was applied to edifices of little importance and rarely in colonnades. I have already cited the Monument of Lysicrates with engaged columns, and the Tholos of Epidauros with an internal order, very interesting as showing how the Greeks conceived an internal cornice, that does not receive rain, but responds to all other needs like an external cornice, and that also exhibits a very simple and very architectural application of the Corinthian capital.

In Italy are Corinthian orders of the republican epoch; tha of Cori is very vigorous, that of the Temple of Minerva at Assizi (Fig. 273) is very remarkable for the arrangement of the raking entablature of its pediment.

The order of the Temple of Vesta at Tivoli (Fig. 275), a circular edifice of beautiful proportions, is very vigorous and in a beautiful style, whose capital is a composition characterized by the use of a variety of curled acanthus, as well as by the character and projection of its rosettes and volute

The Temple of Vesta at Rome is likewise circular and presents an order of slender proportions and beautiful design; its capital is remarkable by the character of the leaves of a pointed acanthus, with the acute angles of the abacus not being cut off.

Then come a multitude of great orders of the imperial epoch

First that of the Temple of Mars the Avenger at Rome (Figs. 4,5), the Temple of Antonine and Faustina (Fig. 52) with six

columns in front, of variegated marble; the frieze of the entablature is ornamented by beautiful sculptures not shown in the adjacent skatch, and the cornice is without modillions. (Fig. 294).

On the contrary, the Temple of Jupiter Stator has a much decorated capital, architrave divided by a sculptured band, with plain frieze beneath a cornice without modillions.

These examples suffice to show the variety of the Corinthian order in the monumental architecture of antiquity. In a more intimate character, at Pompeii are found Corinthian orders of less slender design, particularly in the atrium, like that of the House of the Labyrinth. Numerous examples may be seen in Mazois' work.

Examples might be multiplied, but some suffice, and their actual and proportional dimensions are collected in Tables E. and F. (Fig. 295). (See page 203 for Tables E and F).

I advise you to make similar graphical and numerical comparisons of various examples; you will find a large number and can prove the great diversity in the design of the orders. Varieties that may only be shades, but sufficient to disturb those among you with the erroneous and deceptive idea of a numerical formula in proportions.

The Renaissance made little use of the properly termed Corinthian colonnades, generally treating them in a character rather elegant than monumental. But the examples of the Corinthian order are innumerable, in all the motives suggested by a rich imagination to the architects of the Renaissance. I could fill entire pages with citations having all the dryne of a table of contents.

With the epoch of Louis XIV, the Corinthian colonnade reign as sovereign over architecture. The most celebrated example is the colonnade of the Louvre (Fig. 296) with coupled column it is interesting to compare it with the nearly contemporaneous internal order of the chapel of Versailles (Fig. 56).

In the succeeding century is found the magnificent example of the colonnades of Place de la Concorde, and likewise a composition with the internal colonnade of the hall of the theatre of Versailles. I cite only the most remarkable.

I have connected the orders with the study of proportions; the colonnade is indeed one of the means of composing the por

Temple of [illegible] 2.[illegible]

Temple of Vesta at Rome 3.8[illegible]

Temple of Mars Avenger 4.857 8.30

Temple of Antonine & Faustina 4.[illegible]

Temple of Jupiter Stator [illegible]

Temple [illegible] House of [illegible] 2.23 3.62

## TABLE E.;

## CORINTHIAN ORDERS.;

| Monuments.; | Actual Dimensions.; | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lower diam. of Column. | Diam. of Base. | Inter-columniation | Height of Column | Height of entab.-exc. cyma | Free space between Columns. | Bases. |
| Temple of Assizi | 3.38' | 4.06' | 9.60' | 36.60' | 5.72' | 6.20' | 5.53' |
| Temple of Tivoli | 2.48 | 3.35 | 6.55 | 23.40 | 3.59 | 4.07 | 3.20 |
| Temple of Vesta at Rome | 3.08 | 3.86 | 7.98 | 33.80 | " | 4.90 | 4.18 |
| Temple of Mars Avenger | 5.85 | 8.30 | 14.20 | 57.80 | " | 8.30 | 5.85 |
| Temple of Antonine & Faustina | 4.85 | 6.70 | 12.10 | 46.50 | 10.80 | 7.25 | 5.07 |
| Temple of Jupiter Stator | 4.85 | 6.73 | 12.40 | 48.50 | 11.57 | 7.53 | 5.66 |
| Pompeii. House of Labyrinth | 2.23 | 3.02 | 12.15 | 26.00 | " | 6.63 | 9.10 |

## TABLE F.;

## CORINTHIAN ORDERS.;

| Monuments.; | Ratios.; | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ratio to Diameter. | | | | Ratio to Height of Column. | | |
| | of Inter-columniation | of Height of Column | of Height of Entab | of Height of entire order. | of Inter-columniation. | of Entablature | of entire order. |
| Assizi | 2.84 | 10.84 | 1.69 | 12.54 | 0.26 | 0.16 | 1.16 |
| Tivoli | 2.65 | 9.46 | 1.45 | 10.91 | 0.28 | 0.15 | 1.15 |
| Vesta at Rome | 2.59 | 10.95 | " | " | 0.24 | " | " |
| Mars Avenger | 2.42 | 9.87 | " | " | 0.25 | " | " |
| Antonine and Faustina | 2.49 | 9.57 | 2.23 | 11.80 | 0.26 | 0.23 | 1.23 |
| Jupiter Stator | 2.55 | 10.00 | 2.38 | 12.38 | 0.26 | 0.24 | 1.24 |
| Pompeii | 5.44 | 8.96 | " | " | 0.61 | " | " |

tico, though not the only one. We now have to conceive the portico composed of arches; the same procedures for openings again appear here.

## CHAPTER IX.; ARCADE PORTICOS.;

SUMMARY.-- Porticos with arches on piers.; -- On isolated columns, coupled in width or depth.; -- Mediaeval porticos.; -- Cloisters.; -- Porticos enclosed by columns or pilasters.; -- Importance of the study of porticos.;

For arcade porticos are not found historical or ethnic classifications as for colonnade porticos.; If these porticos can sometimes be connected with the Doric, Ionic or Corinthian families, this is by elements of the columns and entablatures, that are not the portico itself, but are rather decoration than construction.;

Then without classification, let us seek the simplest expression of the portico, which is evidently a series of arches on a row of rectangular or square piers, like the porticos of Rue de Rivoli.;

Not much is to be said here after what has been said of the arch; this motive of porticos in its simplicity appears to have rarely tempted architects, for there are very few monumental Examples. I cannot cite the magnificent Roman aqueducts as porticos, though not differing in composition; the Rue de Rivoli was cited as an example and not as a model; yet some porticos with rectangular piers merit serious study; tha of the lateral facade of the Church of Rimini by Leo Alberti (Fig.; 279), the arcades of the Church S.; Damaso at Rome (Fig.; 297), those of Place de la Concorde; at Venice and elsewhere, notably at the Prisons of Venice (Fig. 298), are some examples of arches on piers with bosses; finally, the second story of the Library of S.; Genevieve, although this may be rather a series of windows than a portico.;

But the inconveniences of the rectangular pier here again call for the substitution of the column for the pier.; Thus we see numerous porticos with arcades on single, coupled or grouped columns.;

The simplest case is that of the single column as in the court of the Cancellaria already shown (Fig. 225), a masterpiece.; I see it as a type and will briefly analyze it.

The shaft of the column is of granite, on the one hand being heavily loaded, this load a guarantee of stability, on the other the shaft being exposed to the thrusts of arches

and vaults in spite of metal ties, it requires to be monolith to act as a sort of rocking strut in case of need, while if they were in courses the least horizontal force might disloca them. The base and capital are of marble.

The capital is higher than in the ordinary Doric order; between this granite shaft and the arch, the construction would be badly proportioned with a low capital, for such a low course might be fractured.

Between the capital and arch is nothing, the capital directly receiving the impost. There is no motive for a complete entablature nor even for a simple architrave, whose purpose is always the connection of two columns.

This portico is faultless in taste, being by Bramante, logical in composition, and it should be regarded as a type of arcade portico with simple columns.

You will again find very pretty examples of porticos thus composed in Tuscan architecture; the works of Reynaud, of Famin& Grandjean exhibit some of extreme elegance. In very monumental treatment may be studied the superposed porticos of Palace Doge at Venice (Fig. 221).

But the portico with simple columns is not always possible, and one is frequently led to couple them in two directions, on the facade or in depth.

It is certain that the arcade portico does not permit the use of very monumental columns, since they can rarely have a height exceeding two-thirds the total opening. If rather slender, especially in the ground story, they are exposed to a certain rocking, and porticos with simple columns are alway quite bold. Naturally greater width was sought for the piers, the means being to couple the columns.

Further, a portico like that of the Cancellaria only permits narrow imposts and consequently small bed planes. very hard stone is alone suitable. These are the causes of coupling in the direction of the facade.

Coupling in depth is often required by the thickness of the wall above or the thrust of the vaults.

In piers so composed, the columns should be combined, and the architrave is necessary to form again the springing of the wall. Thus notable in Genoese architecture are numerous examples of piers composed of two columns with a simple arch-

itrave supporting the springing; on others is a complete entablature, or the frieze alone is omitted. The cornice then forms an accented impost. In such a case the architect employs the complete entablature, if he desires to give the impost an important value by projection; but he limits himself to the architecture, if he prefers to not divide the height of the story by a strong projection. I will cite as examples the coupling in the direction of the wall, the open loggia of Villa Medici (Fig. 299), so interesting in many respects and represented here without the reliefs decorating it, Palace of University at Genoa, whose general arrangement is admirable (Fig. 300), finally one of the vestibules at the Louvre (Fig. 301).

For the case of coupling two columns, one behind the other, it occurs when the wall has a thickness greater than permitted by the diameter of the column. But the design of the portico recurs to that with simple columns, if the two columns are connected, and therefore an architrave at least serves as an impost for the springing of the arches.

There are few examples of coupling in both directions, which recurs to the pier of four columns; rather are found piers with four engaged columns placed at the angles of a solid square nucleus. These piers then have the arrangement of those to be seen in another vestibule of the court of the Louvre (Fig. 302).

In these examples, the arch is such as it would be on a square or rectangular pier, that has hollows or is combined by coupling, but the architraves restore the wall, and the hollows of the pier do not continue in the archivolt, excepting when the principal arch is stepped. Here again as forthe architrave of the orders, the thought is to reform the wall; the openings of the portico are assumed to be in a solid wall

In the arcade porticos of the middle ages, the spirit of the composition is different. To each element of the pier corresponds an element of the archivolt. Thus as a principle in that architecture, to a plan of the pier A (Fig 303) corresponds a section B, reproducing the projections and recesses of the plan, except the squaring of the rounded parts. This is not absolute, but at least is the spirit of mediaeval construction, very different from that just examined.

Further, in mediaeval porticos is a variety of combinations even greater than in the porticos of antiquity or of the Renaissance. Even the number of these combinations makes it difficult to determine their principles, but it is necessary to do so.

While in Byzantine architecture, for example at S. Sophia of Constantinople, or at S. Mark (Fig. 304), in the Sicilian architecture of Palermo (Fig. 305) or of Monreale (Fig. 6), this is still the simple column with capital having a very energetic abacus, supporting the springings of the arches of rectangular section —— in Romanesque and especially in Gothic architecture the arches are increasingly moulded and independent; the piers then almost always consist of a certain nucleus surrounded by slender projecting and much varied columns, that are at different heights the starting points of corresponding arches.

Here (Fig. 307) are some of the most common sections of pie taken from piers of churches between the central and side aisles. There may be found all the elements of the architecture of porticos as just indicated. Later in the 15th century, for example at the Church Notre Dame of Brou, the pier and are no longer separated, there being neither imposts nor capitals; this may be said to be the application of the architec ture to porticos.

A celebrated example of the arcade porticos of the middle ages is the Loggia of Lanzi at Florence (Fig. 308). I can cite none more beautiful. The principle is the same, identical sections of pier and of arch. These combinations further vary infinitely, and by their diversity even escape theories of entirety, excepting the rights of construction.

A very particular variety of porticos is produced by the architecture of cloisters.

Evidently some cloisters are only treated as ordinary porticos and are often very beautiful in the different Cistercian monasteries of France and Italy, as also in numerous convents. But the cloister also frequently has an entirely special appearance; the portico is more enclosed, bays are smaller, or again there are two or three arches to each bay.

Piers are set on a base wall, except at special entrances; the architecture is intimate, while leaving great width for

the walk. The wall of the cloister is unusually thick, so tha the columns of the cloister are coupled in depth, their slenderness frequently contrasting with the strong piers supporting the springings of the arches.

Among so many examples, such are the cloisters of S. John Lateran at Rome (Fig. 309), of S. Trophime at Arles, those o Puy, Moissac, Montmajour, and of the Cathedral at Laon )Fig. 310), or in a quite special form, the little cloisters of Semur (Fig. 311), of Mont S. Michel and so many others. Even i Paris may be seen in Rue des Archives the pretty cloister of the old house of the Billettes. A cloister with a very particular arrangement is that of the Convent della Pace at Rom by Bramante. A drawing borrowed from Letarouilly will dispen with a description (Fig. 312). It will be necessary to retur to cloisters in speaking of religious architecture, and at present I merely mention that variety of the architecture of porticos.

In Italy, the portico often takes the name of loggia, this name being reserved for porticos for pleasure or rest, rathe than passage. Thus for the Loggia of Lanzi at Florence, the Loggia of Verona, the Logetta of Venice at the foot of the Campanile, or the loggias arranged in the upper stories of edifices, not intended for passage but for pleasure, usually facing fine views.

Nothing is more varied than porticos, both in their programmes and their expression. Only by a knowledge of the most beautiful examples can you form a true idea of this diversity, and of all the resources placed at the command of architects by this precious element of the portico.

So far I have only mentioned arcade porticos on piers, columns or pillars. Another equally varied element is that of the arcade with the use of the orders, by means of engaged o free columns or pilasters. The order here plays rather an ornamental part; the architecture of arcades is expressed by elements appropriate for the architecture of the plat-band. A certain contradiction cannot be denied, that purists have believed themselves able to condemn. This rigorism is excessive, for it greatly lessens the patrimony of architecture, and it is truly severe to proscribe a motive producing the Theatre of Marcellus and the courtof Palace Farnese.

It is always evident that the arcade portico never received from antique architecture an unchangeable consecration like the portico with lintels. What would have been its expression if the arcade portico had been contemporaneous with Peastum or the Parthenon? None can tell. Appearing later, it received or submitted to forms and an artistic composition never created for it; nothing better was found than to apply to it also the admired arrangement of colonnade porticos. Doubtless a result of respect for traditions and a kind of instinc for unity in architecture. But the purity is evidently no longer the same, and we do not find that sovereign reason, that permitted me to demonstrate the reason for each element of the antique order. Then the elements of the order employed retain their magnificent forms, but they no longer have their functions.

But it does not matter, and I have to show how this motive has been employed in various ways, according to the idea dominating the thought of the architect. Without entering into a detailed examination of all the beautiful examples of porticos of this kind, I present two very different types, already cited, the Theatre of Marcellus and Palace Farnese.

At the Theatre of Marcellus (Fig. 45) the construction of the arcade is most apparent; piers are wide and the imposts are accented; the annular archivolt has all the depth required by the strong construction. The column is unimportant in comparison with the elements of the arcade.

In the court of Palace Farnese (Fig. 46) the effect is entirely different; the arcade is only a filling within the ver strongly accented architecture of the order. The pier is narrow and the archivolt has only the minimum depth necessary for the contact of the voussoirs.

The first example may be said to be arcades accompanied by columns, the second being colonnades in which are arches.

I cite again the portico with pilasters of Church Ara Coeli by Vignola (Fig. 313). It is here evident, that the use of pilasters leaves to the entirety of the pier more unity, and that the order counts less than with the use of the column.

The order has frequently been employed as an outlining motive, as on the beautiful facade of Church of Rimini, treated as a sort of portico and previously shown (Fig. 279), the

refined portico of Spoleto attributed to Bramante, and by contrast, the slightly heavy ones of Place du Carrousel. Nothing is more legitimate, for thus is avoided the overhang of the entablature, whose architrave does not here fill the function of a lintel, and that can be merely an overhanging projection further the general projection of the column with or without pedestal and its entablature forms at each bay a very useful buttress, when the vaults of the portico concentrate their thrusts on the piers. Then the column may be even free, the buttress is only more powerful, and the monumental effect has great richness. Such is the motive seen on the Arch of Triumph of the Carrousel.

As for the numerous examples of arcade porticos with free columns and entablatures not profiled, I cannot recommend them, in spite of all the talent sometimes displayed there. Such is the celebrated porch of Church S. Gervais in Paris. The contradiction is too flagrant between that arcade and the larger platband, there indeed jointed as such, and no longer an ornamental projection. The law of necessary proportions is scorned, not with impunity. This combination is found in beautiful edifices at the Invalides, Versailles, etc. That does not suffice to authorize it, and it always remains nonsense.

Many other arrangements have been imagined for porticos, arches between coupled columns, motives of alternating bays, large ahd small arches, but I cannot enter into all these variations. Some words only on porticos with bosses.

I shall not return to what was said on the study of bosses themselves. For the portico have been made different studies, that can be comprised in two classes, those with bosses on columns, piers and voussoirs, and those where the columns remain plain or fluted with bosses only on the arch, or on the column alome. Evidently the bosses over all has more unity and character; the most beautiful example is perhaps the Gate of the Farnese Gardens (Fig. 314), or the Gate of the Citadel of S. Andrea at Verona by Sanmicheli. Very interesting is also the court of Palace Pitti with its square bosses of unusua vigor, and at Verona the beautiful ground story of Palace Bevilacqua (Fig. 315). As for mixed combinations, considerations of the entirety in the general design of a façade may sometim

dictates a somewhat exceptional arrangement.

A delicate question to solve in the design of arcade porticos with engaged columns is that of plain or fluted columns; Beautiful examples of both kinds exist; from antiquity are the fluted column at the Tabularium, the smooth column at th Theatre of Marcellus, the Colosseum, etc.

The column is here no longer that clearly defined element of the antique order, the round pier supporting the entablature. Being no more than half of itself, connected to a pier with which it is bound by its jointing, it should rather be absorbed in the architecture of this pier. Fluted, as at the Tabularium and on the second story of the School of Fine Arts it appears as a monolith placed against the wall and detached from the construction, assuming the appearance of an overlay. Thus it seems that the engaged column should logically omit the flutes to preserve with the pier the unity of appearance expressive of unity of construction. Such are indeed the porticos cited as types, the Theatre of Marcellus or court of Palace Farnese.

But this cannot be a rule. The idea of richness may cause the adoption of flutes, and the portico may be joined to a facade requiring its decoration, as on the court of the Louvr the arrangement of the second story does not permit plain columns for the ground story designed like a portico.

You will also find porticos where a small order serves as a pier for the arch between the orders of the general arrangement. A celebrated example of this motive is the Basilica of Vicenza by Palladio, a great hall surrounded by porticos (Fi 316), where the bays have very wide proportions. With a closer spacing, the same arrangement is found on the Library of Venice (Fig. 317) by Sansovino, the starting point for the great edifice of the Procuratio, whose bays have been shown to you (Fig. 20).

You are free, as always, but you should know why you decid in one sense or another.

In terminating this subject of porticos, that cannot be exhausted, all its importance should again be emphasized.

Shall you make porticos, colonnade or arcade? I hope so, for no subject is so seductive to the architect. But I have some doubts, for the portico is never an imperative necessit

and we are in an epoch contented with the glass hood!

But whether you do this or not, in all that you design, whether a fireplace or mirror frame in an interior, the profound knowledge of the architecture of porticos will enlighten and direct you. Centuries have made our art such as you receive from the hands of your predecessors. The subject is then of capital importance; I cannot teach you to design a portico completely --you will be learning that all your life but I have shown the way, if I have clearly indicated your guides and supports; construction, proportion and truth.

# BOOK V. ELEMENTS OF ARCHITECTURE.

Roofs. -- Floors. -- Vaults. -- Stairways. -- Various elem

## CHAPTER I. ROOFS; THEIR COMPOSITION.

SUMMARY. -- Plane roofs. -- Shed roofs. -- Gable roofs. -- Gables. -- Hip roofs. -- Intersections of roofs. -- Hips, valleys, ridges. -- Projections and penetrations of roofs. -- Unequal slopes, intersections. -- Curved roofs. -- Mansard a curb roofs.

Your edifice has risen, great or small, which was the obje of preceding studies of walls, doorways, windows, porticos, etc. All that is vertical architecture, which now must be covered, to protect it from weather and especially rain; the problem is sometimes complex and difficult, but will always be to throw off externally the water as rapidly as possible. This will be attained by the study of the simplest arrangement of the inclined planes of your roofs, even if terraces; for the terrace is merely a combination of slightly inclined planes.

This simplest possible arrangement of the roofs is only obtained by the geometrical study of their elements, excepting for absolutely simple cases, where you will have to take int account by a plan of the roofs their possible forms.

The roofs may be plane, curved or broken, plane roofs bein by far most common, and we will first consider them.

The simplest arrangement of the roof is that with a single slope, termed a shed roof (Fig. 318), like the covering of a portico adjoining a higher building, of the side aisles of churches, etc. But more generally buildings are covered by gable roofs with two slopes (Fig. 319), their line of intersection being a horizontal straight line termed ridge; the roof terminates below at each side in a horizontal eave or gutter. If the building be longest in one direction, the gables should be at the shorter sides, the gutter lines and ridge then being parallel to the longer walls. Thus great spans of roofs may be avoided and the easiest solution be attained, preventing great heights of roofs resulting from a great span.

Then assuming a rectangular building, the simplest plan is to cover it by two rectangular slopes, the ridge then connec

connecting the end walls, that terminate in triangular gable (Fig. 320). Such is the case with antique temples, and in modern architecture for a multitude of structures, whether ordinary sheds, storehouses, etc., or monumental like most churches.

A square plan may also be covered by two rectangular slope and have two gables. But most frequently a square plan is covered by four slopes forming a square pyramid with an isosceles triangle for each face. This structure is then said to be covered by a hip roof (Fig. 321), and the intersections of the four faces are termed hips.

A rectangular plan may likewise be covered by a hip roof (Fig 322), provided there be no great difference between th sides, but then the inclinations differ in pairs, which neve has so good an effect, if the roof is visible and appears in outline.

When the building has the form of an elongated rectangle (Fig. 323), covering by a pyramidal roof is no longer possible; if gables are not desired, there will be four slopes, tw trapezoids and two triangles, and a ridge lengthwise the buil ing. The four inclinations may be equal, but the end slopes are sometimes steeper.

To complete structures of simple form, the circular edific will have a conical roof; a regular polygon will be covered by a pyramid with as many hips as the angles of the external wall; a semicircle or half polygon at the end of a rectangular structure will be covered by a jalf cone or pyramid joining the longer sides.

But when the composition exhibits an intersection of two parts of the building having equal heights, the roofs also intersect, when the intersection of the planes will always be the edge of a diedral angle, but concave instead of being cor vex like a hip. These concave intersections are termed valley

Thus in the sketch (Fig. 324) two buildings intersect at a right angle, the ridges crossing at the meeting of the axes, and the slopes intersect in the valleys projected at 45° on the plan. If the widths be unequal, then the arrangement may be the same, when the ridges may be at the same height, the inclinations being unequal (Fig. 325), and the valleys not being at 45°, or the roofs may have equal inclinations (Fig.

326), when the ridges will no longer be at the same height; the narrower roof penetrates the wider one, the intersections retaining the name of valleys.

These different combinations may be found in the same plan Thus on a building enclosing a court will be both hips and valleys (Fig. 327), a hip always corresponding to a convex angle and a valley to a reentrant one.

Here is an example (Fig. 328) of a main building with four smaller projections and a middle one of equal width. The hips, valleys, gable, principal and secondary ridges are easily recognized.

In brief, the first study of the roofs on an edifice consists in making a plan of them, in which are taken into account the horizontal or inclined intersections to ensure the flow of the water to the exterior. This study is sometimes c complicated and troublesome.

Further, the inclinations will not always be equal. Assume this plan (Fig. 328) with pronounced inclinations for the principal building and lower ones for the projections. The plan then becomes this (Fig. 329). A mere comparison of the two plans shows their differences and their motives.

Likewise for the pavilion with hip roof at the intersectio of two atructures at right angles, when the ridges may be co nected (Fig. 330), hips and valleys all meeting at one point, but it is evident that the slopes of the hip roof are less than for the buildings Or the inclinations may be equal, when the hips and valleys are projected at 45° (Fig. 331), and the direction of the valleys depends on the difference between the inclinations of the two roofs.

These examples may be varied infinitely, but solutions mus always be sought by the geometrical study of the plan of the roofs. Sometimes complicated as these are sometimes imposed, yet are to be avoided if possible. A consideration that must govern the arrangement and study of a plan is the facility o combination of the roofs.

You can make a useful exercise of these combinations, either by arbitrary assumptions, or by seeking the possible arrangement of the roofs of edifices with given plans. As an e ample is given the plan of the roofs of a portion of a porti **Co** of a church, combiling most of the preceding cases.

Curved Roofs. -- In the preceding, replace inclined planes by portions of cylinders with generatrices parallel to the eave walls, and you will have curved roofs. The hips and valleys will be intersections of cylinders, and if the cylinders have the same sections, their intersections will be plan curves; hence though actually curved, the hips and valleys will be projected in straight lines on the plan, just as if the roofs were plane with equal inclinations.

On a circular plan, the roof will become a surface of revolution, whose directrix may be circular, elliptical, parabolic, oval, etc. Such are domes.

Curved roofs are unsuited for intersections of roofs with different inclinations or rather different sections, for then the valleys and ridges, instead of being in vertical planes, will actually be curves of double curvature (Fig. 334), which produces serious difficulties in construction.

In regard to curved roofs, i.e., with curved sections and thus being cylindrical, a recommendation is necessary. If this curve of the section were a circle, half ellipse or oval in all cases being a continuous curve, -- the inclination is at first very steep, starting tangent to a vertical, becomes nothing at the ridge, there being tangent to a horizontal. Then the water would not run off the upper portion. Hence the two slopes must always form an angle at the ridge, either that the curves form a pointed arch (Fig. 335), or they are changed to inclined planes, tangent or raised a step, the usual case of glazed skylights (Fig. 336). Horizontal surfaces must be avoided in all cases.

In broken (mansard or curb) roofs (Fig. 337), the roof with two gutters has four inclined planes instead of two. The steeper plane is termed mansard, the upper one being the deck

For combinations of rooms, the problems are the same as for plane roofs, and all the preceding examples find here their application.

Yet for intersections of unequal structures, the combinations of plane and mansard roofs may produce different arrangments. Thus in Fig. 338, the ridges of the small buildings range with the edges of the deck of the middle portion, the inclinations of these are the same as for the mansard, the deck alone having a lower inclination.

Further, one has more freedom in effect by raising the deck clearly above the small roofs as shown in Fig. 339, where also the slopes may be unequal as indicated by the dotted lines

Those same principles likewise apply to skew roofs in all their varieties.]

# CHAPTER II., ROOFS, CONSTRUCTION.

SUMMARY. -- Inclined plane with battens or laths. -- Simple shed roofs. -- Trusses. -- Thrusts and ties. -- Polygonal roofs. -- Triangular or mansard trusses, with raised tie-beam -- Distance between trusses.

Principles of Construction of Roofs. -- For either large or small roofs, the problem is always to construct the inclined surface for supporting the covering, and which will be a sort of rough jointed sheathing or of open sheathing composed of strips. The former is necessary for metal, ordinary slates or hollow tiles in the South; the strips support flat or interlocking tiles or wired slates.

Strips or boards are placed horizontally. In the very simple case of narrow shed roofs, the surface is supported by wooden rafters sloping with the roof and spaced 1.15 to 1.31 ft., on which are nailed the strips or boards. The strength or dimensions of the rafters depends on their span, slope, weight of the covering and of accidental loads (passage of men, snow, wind, etc.). But when these factors would require too great sections of the rafters, the slope of the roof would no longer be constructed with simple rafters, but recourse would be had to other means, for rafters must always have small sections.

But this is only practicable for shed roofs, where the rafters rest directly on plates at bottom and top, the latter being set against the higher wall and supported by stone corbel or iron anchors placed at proper distances (Fig. 340). Rafters should not be fixed in the supporting wall, as this injures its stability.

This very simple arrangement is possible because the shed roof does not thrust, contrary to a common erroneous opinion. If in the theoretical roof in the figure, the upper plate be fixed to the wall and the rafters be fixed to the lower plate, it is easy to see that the only movement possible for the roof under the effect of its own weight and of accidental loads would be rotation about the lower plate as a pivot. Very far from tending to overthrow the lower wall, this movement tends to move it toward the middle of the edifice, the opposite of a thrust. If the stability of the lower wall be feared, not

a tie but a strut is required at A. Thus a tie-rod, as for arches, would be useless here, since the member A is in compression and not in tension. This remark is necessary because the contrary prejudice is deeply rooted; since gable roofs exert an energetic thrust if not neutralized, it is erroneously assumed that every roof thrusts.

But in roofs with several slopes are required carpentry frames of wood or iron to support the ridge and all other elements of the roof. Assume a roof on a building 50 to 65 ft. wide, when the rafters will have a length such that they cannot support themselves; it is necessary to rest them on a series of horizontal members termed purlins —— the ridge being a purlin, —— that have a larger section than the rafters.

If there be in the edifice cross walls sufficiently near together, that the purlins may span the distances between them, the roof may be constructed of purlins and rafters. But if these walls do not exist or are too far apart, the purlins must rest on frameworks, which are trusses.

Thus a complete roof consists of:——

1. Trusses, vertical frames of wood or iron and regularly spaced, their upper outline resulting from the inclinations of the roof planes.

2. Purlins, horizontal members extending from one truss to another and fixed in the gable walls, when the roof ends thus. The number of purlins varies according to the width of the roof plane, their spacing being generally about 6.6 ft. for roofs with wooden rafters. In any case, there are purlins at the bottom and ridge. When the roof is a mansard, a purlin is required at the intersection.

3. Finally, rafters of small section extending in the slop of the roof.

Hips and valleys require hip and valley trusses.

On this entire framework comes the covering.

I stated that the shed roof does not thrust, but on the contrary the gable roof thrusts and tends to overthrow the walls unless neutralized. Assume two inclined planes, like two ston slabs, set between two walls and resting against each other at top. (Fig. 341). By their weight these planes tend to sink, but cannot do this without spreading the base of the triangle; thus they thrust against the walls, and unless thes

are strong, they will be overthrown or spread apart and the roof will be deformed. On the contrary, if the system (Fig. 342) were of a single piece or indeformable, it might be simply placed on the walls as a covering, producing only a vertical force by its own weight and no thrust.

These theoretical considerations are necessary for taking up the composition of trusses. There result two principles:-- 1. That the thrust must be neutralized as shown later; 2. That every framework must be indeformable. The triangle alone possesses that indeformable property and will be the unit of the combinations.

I will add that on any plan of a regular hip roof, from the triangle to the polygon with many sides, producing a pyramidal roof or formed of cylindrical spindles ), the thrust may be suppressed by an indeformable tie surrounding the base of the roof. Thus for an octagonal hip roof (Fig. 343), however energetic the thrusts exerted by the hip trusses, they have no effect on the walls, since for one of the trusses to spread, it is necessary for the tie to stretch or break.

The hip roof may then be constructed without thrust, and this is very important, permitting the use of the spacewithin the roof.

After these explanations, we can take up the study of trusses.

Combination of Trusses. -- You have two parallel walls with neither points of support nor cross walls between them. The interior must be free for halls. There remains for the framework an attic above these halls. The truss may be termed a vertical division and will then be a triangle, the simplest case. (Fig. 344).

The width of the roof plane is assumed to require a plate, two purlins and a ridge, with a principal beneath the purlins The two principals then join beneath the ridge, but an end joint is bad, and they are connected by means of a vertical member termed kingpost, this framing being strengthened by struts. All these members in the same vertical plane support the covering.

But stooping there, the principals would tend to rotate about the joint, thereby against and tending to overthrow the walls. Hence the feet of the two principals must be connected

by a horizontal member named tie or tie-beam, whose function is to prevent the spreading of the walls. Since it might bend by its own weight and length -- which would draw the wal together -- the kingpost supports it at the middle of its length, and if this suspension be not sufficient, intermediat ones are provided.

This study of a very simple truss exhibits the principle to guide you always, that of combining triangles, for in construction it is always necessary to assume hinged joints for the framework.

For great spans, the combination will be more complex, but always easier with the tie at the base of the roof. For example, examine a combination applicable to a truss of very great span (Fig. 345).

For a mansard roof a complete division into triangles will not be possible, for the purpose of such roofs is to allow usable spaces in the roof itself, but it is necessary at least to strengthen the framework by combination of trusses. (Fig. 346).

Finally, the requirements of construction may require the tie-beam (that supports the beams of the last floor ) to be placed below the base of the roof and with an inclined tie (Fig. 347) without injury to the tie-beam or at the bottom. It will be the same in the truss of a mansard roof (Fig. 348) But though these combinations are often necessary, they are not so good in theory and require more careful study.

Iy does not fall within the limits of this book to show you all the varieties of trusses. These examples suffice at present to show what a roof is. All the preceding is further base on construction in wood, but with steel if the sections and connections are entirely differebt, the principles remain the same. It is always first necessary to seek indeformable combinations, and to avoid the dangerous thrusts of roofs, whose ties might not be sufficient.

As to distances between trusses, this may vary much, being a question of strength of trusses and purlins. But one consideration must precede all others, the truss must rest on th resistant points of the construction, and consequently be placed on the points of support of the bays of the facades. When hipped roofs exist (Fig. 349), it is well for the half

trusses to unite by means of a verticalmember common with the first complete truss, though this arrangement is not always possible. The requirements of the plan may well precede considerations of easy execution of the framework.

This slightly premature study of roofs could not be omitted though later pursued in stereometry and construction. It is necessary to design entireties that may be built, which is all that is first required, but later you will learn to ensure the construction.

## CHAPTER III. ROOF COVERINGS.

SUMMARY. -- Flow of water. Continuous drip. -- Roof coverings with antifixas or gutters. -- Crown moulding and groove. -- Gargoyles, leaders. -- Monumental roof coverings. -- Inclinations required. -- Great inclinations, terraces, mansards and decks. -- Habitable attics.

Drips, Gutters, etc. -- Formerly in antiquity or the middle ages, men were contented to allow the rain water to gall off along the eaves of the roof, either uniformly along its entire length or at certain points, where the water was concentrated by means of gutters, and from which it was thrown off by garhoyles projecting more or less. This method is no longer tolerated today, and the rain water is collected in gutters at the bottom of the roof, then being removed by leaders discharging at the base of the building, or better into a subterranean sewer. Direct drip is rarely permitted on projecting roofs, never on a public way. With direct drip, the base of the building must be protected against stagnation of water falling from the roof. Inclined and very tight paving is indispensable, as well as efficient drainage by channels, sewers, etc.

Antique roof coverings are of two sorts from this point of view, those with continuous drip and antefixas, or those with gutters with a cyma.

The antefixas (Fig. 350) are vertical ornaments placed at the ends of each row of covering tiles or of metal sheets; water runs down between the rows. This system is that of the great Grecian temples, excepting when the tiles, cover tiles and antefixas are of marble.

When the water is thrown off by gargoyles, there is a small gutter, always of little importance, the gargoyles being very close together and consequently not having much water to discharge.

This small gutter is the cyma gutter, a well known example being that of Metapontum (Fig. 351), that consequently forms part of the roof and not of the entablature. Indeed examples of the cyma gutter are of terra cotta or metal, when the entablature is of stone. It is quite true that custom finally regarded the cyma gutter as the upper part of the cornice, and that as a modern error, even internal cornices always ter-

minate in a cyma gutter. But it is necessary to recall its origin to take account of certain architectural arrangements, notably that of the pediment, to be mentioned later.

The leaders now being necessarily farther apart than the ancient gargoyles, the gutters must be more important, for they receive more water and their necessary slope requires depth. This slope should never be less than 2 per cent. Gutters have then assumed great importance, being actual channels above the cornices, and they may be of stone, wood lined with metal, etc. You will see later that they have given occasion for very beautiful motives for the decoration of facades.

As for construction, it is better for the gutter to be on the cornice and not on the wall (Fig 352); leaks are then of less importance, and they are seen more promptly. Further the depth must be according to the distance apart of the leaders, but this should not be excessive. This is often one of the greatest difficulties in the designs for facades, and it is necessary from the beginning of composition to foresee the possible locations of the leaders. This is too frequently neglected and trouble follows.

As a summary, the removal of water is the problem, formerly very simple, the water being led by the roof slopes to a projection beyond the walls of the edifice to fall where it might; so much the worse for passers.

Such was the arrangement on the most perfect edifices of antiquity; on the Parthenon the roof covering ended with a last or rather first range of marble tiles with antefixas at each end of the cover tiles. The water then fell uniformly along the length of the roof.

Even on the most important edifices, such as the Pantheon of Rome, Baths, Basilicas, other errors do not appear; and in the Renaissance the edifices most directly inspired by antique architecture, for example, the palaces of Rome, were conceived with a direct discharge of rain water on the public streets. Such were still the projecting roofs of Tuscany. At Fontainebleau a large part of the buildings has no other escape for the water. Today these edifices are generally disfigured by frightful gutters, which we may regret as artists, but it must be admitted that the passers have some rights to

not be overwhelmed, and that solutions more careful of the public ways are imposed upon us.

In the middle ages, the public street also received the discharge from the roofs, but it was no longer a uniform drip, for short gutters concentrated the discharge of water at definite points, at each bay of the edifice. The gargoyles receive the water and project it far from the walls, as on the Hall of the Synod at Sens (Fig. 353) or at Museum Cluny in Paris (Fig. 354). The water no longer fell everywhere, but more thickly. This arrangement is that permitted by the great dormer windows in the plane of the walls, to be seen on many mediaeval edifices and on French Renaissance chateaus. The water from the roof was collected between the dormers and ran off there. Examples of the same kind may be seen on numerous Renaissance chateaus, among which I cite that of Pailly with its great central dormer (Fig. 355), as well as the imposing facade of the Chateau of Maisons (Fig. 356), and you may again be convinced of the effect of a structural element on the architectural composition itself.

But the same facilities are not granted to us, for the water from our roofs must be conducted to the sewers without the loss of a drop. Hence the entirely modern elements of the long gutter and the leader.

Roofs are a primary necessity, and they may also be an art element. Antiquity seems only to have known the merely utilitarian roof. Admirably conceived for execution, it counted for very little in the appearance of the monument, no more than that of the Madeleine in Paris. It was the same in Byzantine architecture (perhaps excepting the domes), in that called Latin, and even in the earliest Romanesque edifices. The inclination of the roofs soon became more pronounced, and the middle ages and Renaissance present numerous examples of roofs, not only conceived for covering the edifice, but also for adding an important element to its appearance and outline. Then occurred a disappearance of accented roofs, and for a long time the roof was regarded as negligible for the appearance, it being even admitted that the first care of the architect was to conceal it. Our modern architecture has restored their artistic importance to roofs, though sometimes abusing them like all good things.

Roofs may be an artistic element of great value; from the moment when accented enough to be seen, it was necessary to harmonize them with the outline and beauty of the edifice. All our great churches may be cited, and examples exist at each step. At different epochs and in very different styles, view the roof of the S. Chapelle (Fig. 357) and that of the chapel at Versailles (Fig. 358). The idea is the same. Also see the grand roofs of the City Halls of Paris, Ypres, Louvain and Brussels (Fig. 359). These examples suffice to show what a beautiful and rich part is due to the roofs. Some are also very ugly and crush the edifice, yet it is rare that clearly accented roofs do not benefit the appearance of a monument.

You will likewise see beautiful mansard roofs, as on Chateau Maisons, Palace Luxemburg, Pavilion of Flora and Gallery of Apollo at the Louvre.

The architect then proposes two questions in regard to his roofs; what will be their arrangement for prompt removal of water, and how must they harmonize with the effect of the edifice? These questions lead to another; what will be the inclination of the roofs?

For the removal of water, the inclination must always be more than sufficient. Flat roofs are always dangerous, the least defect assuming great importance. Then they must sensibly exceed the minimum generally adopted, about 30 per cent for metal, 35 to 40 for jointed tiles, 50 to 60 for flat tiles and slates. It is not only necessary for water to run off rapidly, but the roof covering should dry rapidly, and it will do this only if much inclined. In your designs are frequently noted inclinations much too small.

Terraces are very dangerous and should not be rashly constructed.

Terraces formed by large and very slightly inclined planes, such as can be made of mosaic or with a covering of cement or asphalt are only possible for immovable surfaces, like the mosaic terraces of certain parts of Roman Baths. Yet it must be stated, that the inevitable leaks through holes or cracks are absorbed by enormous masses of the vaults, as well as that the climate of Italy is not that of France.

On less monolithic structures, particularly if the terraces

are supported by floors, this system must be changed to steps, the terrace becoming a sort of staircase of low risers. Yet this is not without inconveniences, for if the stone joints open, and few stones are not porous. With metal all accidents from expansion and bulging are possible.

Beware of terraces, for those of the Arch of the Star had injured the monument apparently eternal, there being only just time to remedy them.

Further, if terraces be constructed with all possible care, they retain their inevitable inconveniences. Dust in summer, leaves in autumn and snow in winter are collected, always threatening to fill the gutters and leaders of the edifice, with leaks, etc. Vigilant oversight is required with frequent sweeping. Since the terrace invites walking, this introduces boxes of flowers, and soon on the terrace are deposited all sorts of things to injure it. As for removal of water, this is always doubtful, and the great roofs of Versailles show miserable expedients for avoiding visible roofs.

Yet everything said of inclinations may appear contradicted by countries with great snowfall, where the roofs are generally quite flat. This contradiction is only apparent, for in Norway the snow of October is covered by that of November and thus until the great thaw in the spring. If the inclinations are steep, then occurs a dangerous fall of blocks of ice, the roof becoming an actual glacier. But if the inclination is small, the icy snow melts slowly in place without falling. A question of climate. An analogous motive in certain countries with persistent snow, terrace roofs are made, so that the thick mass of snow in layers forms a natural defense against cold. This seems a paradox and yet is physically true, the snow being a bad conductor of heat. But these are exceptions and local customs are based on local experience.

On the contrary in normal conditions, great roofs are evidently excellent for the protection of the building and also very noble in appearance. Observe from a distance the roofs of Notre Dame, S. Eustache, Chambord, (Fig. 360), the City Hall and the chapel of Versailles. What fine accenting of the edifice sheltered! Particularly when to them is left their beautiful character as a covering without loading them with heavy ornaments.

They have the fault of greater cost by the volume of the framework and the area of the covering. Therefore they are utilized, hence attics in roofs.

Roman antiquity was acquainted with lateral gables on cross vaults, such as seen on the halls of the Baths, but it may be said that the middle ages created dormers, thus permitting the use of roofs, and the Renaissance did not fear to install several stories in the height of roofs, in several city halls in Belgium being as many as four rows of dormers, corresponding to four stories, one being at the level of the base of th roof, and the others being formed by floors resting on the successive collar-beams of the trusses. But with gable roofs, even if very steep, the stories are rapidly narrowed and the depth of the dormers becomes great, making ventilation and li ing of the rooms very difficult. Hence the mansard roofs composed of two steep and two flat roofs.

Indeed the steep side is almost a wall of wood or iron, and the deck covers nearly the entire area of the edifice, so that few reasons exist for not simply adding another vertical story instead of the mansard. But there may be requirements for the facade, that determine the height of the beginning of the roof, and then the mansard roof can be utilized better than the gable roof (Fig. 361).

But one should be convinced in general, that where it is not to be made a habitable attic, there is no occasion for a mansard roof. The gable roof is more simple in construction, more stable, and has a more frank appearance; for proof compare the great roofs of the churches just mentioned with the mansard roofs of the new Louvre.

The cylindrical roof has some analogy to the mansard roof. The section of the cylinder commences with a nearly vertical part, while the inclination diminishes toward the ridge, but must always be an inclination, so that the section of the roof cannot be a simple curve tangent to a horizontal at top; it must have at the ridge the intersection of two slopes. The conditions for utilizing it are then the same (nearly) as for mansard roofs, the appearance alone being different as well as the design of the trusses. The cylindrical roof is used either on extended structures like the houses of the old Rue de Rivoli, the old Palace Champs-Elysees, or the

celebrated Basilica of Vicenza by Palladio; also on square pavilions as at the Louvre, Palace of Justice (Fig. 362), or the central pavilion of the Ecole Militaire, a beautiful monument unfortunately sacrificed by everything concealing it on all sides (Fig. 54). In the last case it is almost a variation of the dome.

# CHAPTER IV. DOMES AND SPIRES.

SUMMARY. -- Covering a circular plan. -- Cones and polygonal pyramids. -- Antique domes. -- Pantheon, S. Sophia. -- S. Peter. -- Construction and outline. -- Spires. -- Decorative character of modern roofs.

At the end of the preceding Chapter the word dome was used in speaking of roofs with four cylindrical sides. This naturally leads me to speak of the roofs of circular edifices. The simplest case is the conical roof, flat or steep. Numerous examples occur even in Paris; the towers of the Palace of Justice, circuses and panoramas. Sometimes the cone is rather a pyramid with polygonal base and a large number of sides, as at the Circus of Filles de Calvaire (Fig. 363); there it is a motive of construction, so that the sill and each series of walls form a permanent and therefore indeformable enclosur I know, and can cite no examples of mansard roof on a circular plan.

On the contrary, domes are numerous, and this is one of the most beautiful motives on which the architect can exert himself. Here in particular may be seen the profound difference between the antique and modern spirit in architecture.

Antiquity built numerous domes, for it constructed many vaulted circular halls. The most celebrated remains intact ti our time and is the Pantheon of Rome, called the Pantheon of Agrippa (Figs. 364, 365). There on a very thick wall, wisely hollowed out, is turned a hemispherical dome about 142 ft. in diameter. Thus as required by the construction, the spherical calotte of the extrados is not concentric with the intrados, the thickness increasing with the distance from the vertex; then at the critical part of the vault where rupture might occur, this vault is loaded by stepped masonry above the external wall. All this is admirably studied for construction; the architect has satisfied the construction, neither more nor less.

And on this sufficient and necessary construction he has placed sheets of metal to cover the monument without any care for the external effect or appearance.

And that is all, just in the antique spirit. Indeed, I know of no edifice where the disdain of appearance and seekin

for effect was carried farther than on the Pantheon of Rome. It was finished by marble facings. The monument thus received a surface decoration, yet absolutely nothing was designed with the view of what moderns call the outline or the picturesque.

By the beautiful works of M. Chedanne, I know that the Pantheon now seen is only perhaps an unfortunate rebuilding of a preceding monument, and that still called Pantheon of Agrippa is actually an edifice of the time of Septimus Severus. But if I am very grateful to M. Chedanne for having corrected the traditional admiration of the quite mediocre architectural details of the colonnade of the Pantheon, yet it no less remains, that the composition of the rotunda must be nearly as now seen, for there is the antique spirit, absolute disdain of outline and effect.

Not that I desire to state that antique edifices have neither outline nor external effect; onthe contrary, they frequently have much of these; but by the force of things, by an unsought result of means employed to perfectly ensure the utility of construction, and by the intrinsic beauty of a superior truthful expression, imposed in spite of all. That architecture first seeks utility, then magnificent interiors enjoyed by the people; at the service of that magnificent utility are placed the means of a powerful construction; if there be a grand external effect, outline and picturesque appearance, these are additional, and because they could not be oth erwise.

Such is again that other admirable monument, S. Sophia of Constantinople (Figs. 366, 367, 368). With all its elements of construction and placed on one of the hills dominating the Bosphorus and the Golden Horn, it indeed produces an admirable effect. What seems to be composed so happily for appearance and effect is simply the construction required, without a single stone not indispensable to the construction. Here again with construction alone, nothing more nor less, see the appearance of the monument, admirable but unsought, neither sacrifice, concession, nor even care for the appearance.

Now at a few steps from the Pantheon of Rome, behold that other monument, also modern -- S. Peter of Rome (Figs. 369, 370, 371). This is likewise a dome, even"The Dome" as the

Romans say. Consider it now only for the dome, for its general composition will be treated later with religious architecture, as well as S. Sophia.

Here the effect is the entire programme, for "the dome" not only indicates the church, but at a distance of 45 miles announces the city of the Popes, and the centre of Catholicism in that city; it is made to be seen, its normal function and its reason for existence; it is less the roof of the greatest of all churches than the covering and sign of this centre to which converges the entire unity of Catholicism.

Thus it is a roof –– a splendid one –– that in the hands of a Michelangelo becomes the expression of the idea most eloquently proclaimed by the architecture.

What a design of the outline (Fig. 372)! How this monument conceived for appearance is studied for appearance! S. Peter, as a church, unfortunately has parts to be regretted, notably the principal facade, but "the dome" is an absolute masterpiece. I do not know whether, as it is said, Bramante desire to raise the rotunda of the Pantheon on the vaults of the Temple of Peace, perhaps merely a reported phrase, but I do know that Michelangelo has produced a modern work, with the good fortune that cannot betray such an artist, when his own idea is that of his age and his civilization.

Even at Paris itself, nothing is more elegant in appearance or better announces the city than its beautiful domes, those of Val-de-Grace and of the Invalides, the Sorbonne in a lesser degree, the Pantheon, or more correctly S. Genevieve, with a different order of ideas.

I cannot speak of roofs without devoting a moment to spires. Here again roofs of stone or metal are conceived for effect and outline. This is a purely decorative element in the higher sense of the word, the indication of the place of the church, and without going into exaggerations produced by the successive endeavors to surpass the height before attained, it is certain that the spire is a magnificent element of outline and effect. Paris does not possess many, the most beautiful being that of the S. Chapelle, which is not the spire of a great church, but every one certainly knows some beautiful spire, lofty and slender, yet strong, and who may not hav been impressed by the beauty of this motive?

I shall treat these subjects with more detail, domes and spires, when I speak of the churches with which these elements are connected. At present I merely desire to indicate the use to be made of them for outline and decoration.

I have sought to show by these examples that roofs, understood by antiquity as a simply useful element, have become f architects of the middle ages and the Renaissance a beautiful element of the appearance of edifices, new richness added to the means of architectural effect.

But understand fully, that this beauty is in the use, in the frankly expressed proportions, and not in the ornamentation. A roof is beautiful or ugly by its outline, its inclination, the proportions of its hips and ridges. Ornament adds little to these conditions of appearance, but if the ornament destroys that freedom of effect, makes the appearance heavy, undecided outlines that should be clearly marked, then the a chitect has injured his work; instead of a boldly accented roof, he has placed on his edifice a confused mass, injuring the function of the roofs and their effect.

The great roofs of the preceding centuries were generally designed with much sobriety, and perhaps their effect is the more monumental, the more simple and less decorated they are. The roofs have by themselves such an effect of outline, that this is itself the most magnificent decoration of the monument. Useless to overload it, thw ornamentation must at least be judicious in all cases.

It will be logical to apply it to structural parts of the construction. Thus the crockets naturally decorate the hips, just as the cresting ornaments the ridge. Not only are these parts visible and thus authorize ornamentation, but further decoration so placed does not obstruct the flow of water, ridge and hips being lines separating the slopes of the roof. On the contrary ornament applied in the valley is nonsense, being a barrier to the flow of water, besides being placed i a concave angle in a bad position to be seen. It is again logical to decorate the domes, which are accented in the outline, and of which are beautiful examples; similarly for the gutters crowning the facade. But one understands less the ornamentation, that seeks the least details, such as the openings for mere ventilation. In brief, whether for roofs or any

thing else, the function of ornamentation must always be to strengthen the idea of the composition.

## CHAPTER V. ACCESSORIES OF ROOFS.

SUMMARY. -- Valleys. -- Gutters. -- Arrangements to be avoided. -- Location of the gutter. -- Balustrades. -- Conditions of establishing gutters. -- Leaders. -- Access to roo -- Walks. -- Access to attics. -- Dormers. -- Chimney caps. -- Pediments and gables.

Although the theory of architecture comprises all elements serving for the construction of edifices, I do not have to enter here into the details of the construction of roofs. But their arrangement has a great importance in the design of a project. From this point of view, I have to present some observations.

In speaking of composition in general and then as the arrangement of the roofs, I have stated that it was useful for the plan by its simplicity to permit a prompt removal of the water. On the roofs themselves with sufficient inclinations are no great difficulties in this respect. Thus the ridges and hips, the convex angles formed by the roof planes require great care in the execution, but are not a danger to the buil ing. The dangerous parts are the valleys and particularly the gutters, the valley being only a more inclined gutter, always being the channel for the water from the roofs.

Th inclination of the valley is always less than that of the roofs served, and if these are low, the valley is yet lower, but if the inclinations are considerable, the valley is enclosed as the angle between thr roofs becomes acute. The valley is unavoidable but presents dangers; it must be wide and easily emptied, and if a low inclination is sufficient for a simple plane roof, the same slope no longer suffices if the intersections of roofs require valleys.

In general, it may be said, that the most satisfactory combination for roofs is the gable roof or the shed roof, terminated by a gable at each end, then the hip roof either oblon with ridge or pyramidal. Difficulties result from the intersection of roofs, which cannot be avoided and that must be studied with prudence.

But much more dangerous still is the gutter between two roofs, an actual horizontal valley. The least obstacle there to the flow of the water has very dangerous results, for if

it overflows, the interior of the edifice will be injured.

Likewise for gutters against the walls, always dangerous for the same reasons.

Then avoid if possible arrangements of roofs giving occasion for these dangers, gutters between roofs or between a roo and wall. Examples are too frequently seen in your projects.

Note that the gutter itself in the most normal conditions is always not without danger. Scarcely a structure does not at some time suffer from its gutters. Let us examine the conditions of construction of the best, —— perhaps of the least bad.

The simplest gutter is the eave-trough, best practically because outside the construction. It frequently happens that a gutter is choked or bends, but this is seen at the first rain and is repaired. The accident occurred outside, and as the water could not reach its normal outlet, it overflows visibly and without injury.

On the contrary in gutters above walls, especially internal walls, injury has very grave consequences, that may only appear after a long time. Some day the traces of dampness in a hall, perhaps richly decorated, indicate the existence of a leak in the gutter, perhaps for months. But the suspended gutter is ugly, the eave gutter never chokes and may even become a very beautiful motive, that you cannot do without.

The gutter is a channel formed the entire length of the eave of a roof to receive the water and carry it to the leade often quite a distance. This channel is sometimes in hard stone —— extremely dangerous, and stone gutters must be lined with metal. But in spite of all, the gutter is exposed to obstruction by rubbish or dirt, leaves from trees, nests of birds, and by frost. Now every obstructed gutter overflows and this must be provided for.

How shall the gutter be arranged? Just where the consequences of overflows will do least damage, i.e., outside the facade. The gutter replaces the suspended gutter by a more monumental expression, but must preserve if possible the harmlessness of the suspended gutter.

An overflowed suspended gutter injures nothing, and it will be nearly the same if the gutter be above the cornice, outsid the face of the wall. Logically, that is its proper place,

being that of the drip above the antique cornice; a very frankly accented example may be seen at the Library of S. Genevieve (Fig. 374) and also at the School of Fine Arts (Fig 375), as well as at the Palace of Justice.

It is entirely otherwise when the gutter is behind a balustrade. This may be, and I do not think of proscribing a mode for which so many beautiful examples exist, such as most of the churches of the middle ages and the monuments of the French Renaissance, or of the time of Louis XIV. But then the gutter is rarely against a wall and special precautions must be taken. Further, as because of the balustrade itself, one is led to take it as a walk, so that it is necessary that it be made wide and easy.

Finally without being encased, the gutter is set back of the cornice and rather above the wall, which is not so good as if frankly above the cornice. I state in detail the requirements of a gutter, for very erroneous indications of it frequently appear in your studies.

Assuming a rather long gutter and two leaders, there is in the gutter a high point at the middle and two slopes, which are not always mere inclined planes, for the gutter has steps required by the use of metal (Fig. 376). At the proper distances at the laps of the metal bands are formed steps with a slight inclination between them. If an obstruction raises the water no higher than the step, there is no danger, but if it exceeds the step, even if far below the top of the gutter, it would leak between the metal sheets.

Outlets are arranged to prevent this danger, but are usually placed at the top of the gutter, and are then useless. They should be near the bottom and just below each step.

Another necessary precaution is that the gutter next the roof be higher than its front, to obviate the inconvenience of leaks.

Finally, the height of the gutter has a minimum always depending on the length of the slopes. The high point must be an inch or so below the front of the gutter, and from thence to the leader should be a fall of about 2 per cent, including the steps.

Leaders form a great difficulty in the design of facades. Most frequently they are omitted, but although the problem be

difficult, it is not insoluble; yet it must be considered at first, for frequently in the composition itself will be found a possibility of arranging leaders. The difficulty is increased with internal gutters. Beware of a multitude of very seductive motives attempted in the past, when leaders did not exis and which are incompatible with the necessary element. A multitude of citations might be made, such as a circular temple, as at Tivoli, a court with colonnade; how should they be made with leaders? How is the water removed from the Madeleine? Certainly not by simple means or those exempt from da

Leaders enclosed in walls -- often attempted -- are very dangerous and must be absolutely avoided. When it is desired to place them inside, this should be where supervision is eas and where an accident may not have serious results. Actual accessible flues have sometimes been built with ladders. Such is the angle of the Library of S. Genevieve (Fig. 377), where the architect could skilfully profit by the intersection of the internal projections of the edifice to locate the leaders. This arrangement is irreproachable, which permits not showing them on the facade.

Do not mistake, for this question may seem of little importance, but is most serious, and if the composition has not provided for this, the architect exposes himself to grave disappointment.

Another very important question in the arrangement of buildings is that of access to the roofs. For maintenance, sweeping and repairs, it is necessary to go on the roofs without building an external scaffold each time.

Not only is access necessary but also walks, for without them, the passage of workmen is a danger for the men and injures the coverings. Horizontal walks are determined by the gutters and ridges with steps on the slopes. When the programme requires frequent visits, even of daily inspection, these walks cannot be too seriously studied.

These prudent precautions are always useful, and they are even required for some edifices. Thus on theatres , it is prescribed to arrange walks protected by railings.

It is also an imperative necessity for glazed roofs, whose maintenance is always dangerous, but still more so unless wis ly arranged walks permit to repair with all possible safety

the glazing of the roof.

I add also that roofs must also be easily accessible. It is not sufficient to go on, but also under the roof. Thus at the Madeleine or the Orleans Gallery of Palace Royal, a workman can only with great difficulty pass in the small space between the ceiling and roof, yet this is necessary.

Likewise for dormers, the design must always provide for removal of water. The dormer is a window enclosed by wood or stone and terminated by a small roof penetrating the large one. Most frequently the face of the dormer is a gable covered by two slopes and joined to the great roof by two small valleys. The water falling on the roof above the dormer is then thrown off at right and left. When the water is simply allowed to drip or gargoyles are used, this is very simple, and thus the great monumental dormers of the middle ages and of the Renaissance rise in the plane of the facade crowned by their masses. I have already cited examples of great dormers, that are in a way gables; in the more ordinary function of dormer windows are found infinite examples. I will cite among the French chateaus, those of the Chateau of Tanlay (Fig. 378), of Mansion Ecoville at Caen (Fig. 379), and those of Fontainebleau (Fig. 380) next the garden of Diana; it even occurs that a window in a vertical story forms a sort of dormer by its cap alone, as on the House of Consuls at Chartres. But with our leaders, this is impossible without one for each bay. We are then compelled to carry the gutters across the dormers. That is less beautiful, but is frankly a part of the facade and almost interdicts great monumental windows. They remain quite possible at the end facades of a bay, or in the middle of its length, wherever the gutter has a high point for it may be interrupted there without inconvenience. Such is the case for the angle pavilions of the City Hall of Paris (Fig. 381).

In regard to roofs, the chimney caps should again be mentioned. That is a study too frequently neglected, and the reality cruelly punishes the architect, who has not foreseen it. Too frequently the chimney caps are treated as negligible, or even are said to be ugly, and that all design would be sterile. No indeed, for it is certain, that chimney caps are seen and count for much in the appearance of the edifice; it

is also certain, that they may be arranged and be treated, even being elements of beautiful motives, like the beautiful monumental chimneys of Chateau S. Germainn (Fig. 382), those of Chateau Martainville (Fig. 383), both of bricks, those of Chateau Anet (Fig. 384), of +hambord (Fig. 385), of the City Hall and Pavilion of Flora of stone, and many others. Even the chimneys designed with less luxury but respect for necessity still contribute to the appearance of the monument, for example those very simple and frank at Fontainebleau. Then they are necessary and you will not escape the difficulty by neglecting their design. You have too much the habit of studying your facades, omitting chimney caps, an old error that nothing can excuse, and which must indeed be renounced.

Abutting or engaged, chimneys leave the roof best if the width of the cap is in the direction of the slope of the roof indeed the obstacle opposed by the cap to the flow of the water is reduced to its thickness, while if it pierces the roof on a horizontal of the plan, its entire breadth stops the water and snow, and may often be several yards. In this case it is best to construct behind the cap a little penetrating roof with two valleys to throw the water to each side, and with a sufficient slope.

It is then by the study your plans of the ground and other stories, that you should consider these caps, and if your composition permits, provide them in the best direction. Thus here again is required foresight. The appearance of the roofs and of the chimney caps will first depend on the arrangement adopted in your plans for the distribution of the walls. These will not be the primary considerations, but if in the arrangement of your ground floor plan, you have ensured regularity in the location of the walls, you will no longer have the difficulty resulting from the design of roofs with flues issuing from indeterminate points of the roofs, and it will only remain for you to design the caps themselves.

Now you know that a chimney, to not be exposed to reversed drafts of smoke, must dominate the adjacent ridges. Then high chimneys are necessary, especially if the inclinations of the roofs are pronounced. One must not evade the programme, but must accept it resolutely. Your chimney caps will count in the appearance of your edifices; do not leave that to chance,

and remember that a chimney flue may become a beautiful architectural element, as at the Louvre, the City Hall and many others.

It is difficult to obtain an idea of all the details requiring a plan of the roofs; in an important edifice, this is a considerable entirety, that increases in time, for something is always added. To give an idea of this complication, I exhibit a very complete and reasonably accurately drawn plan of a portion of the roofs of Palace Royal (Fig. 386). It is a simple psecimen of what might be shown by many other plans of the roofs of a great edifice.

Finally, I have reserved for the study of roofs questions relating to gables and pediments, although these are parts of walls, because there the walls are subordinate to the roofs.

In principle, pediment and gable are synonymous terms, always being the usually triangular arrangement of the top of a front wall, whose outline is determined by the adjoining r roof, or in other terms, it is a transverse section of the roof appearing on the facade.

Pediment or gable should always have the same slope as the roof, and such are the Greek pediments and the gables of the middle ages.

Yet the beauty of the pediment motive has seduced architects, even when their composition did not lend itself to its logical use; perhaps by accustomed eyes, we do not tolerate a pediment with pronounced inclinations; from this came the use of the purely ornamental pediment, often even by the penetration of its rather low inclinations into a much steeper roof, as at the Louvre, Palace Royal and Place Vendome (Fig. 387), etc. Very frequently even a pediment crowns a motive projecting from a higher building; it is then attached to a wall, or again it merely crowns a doorway, window, or some ornamental motive.

But in all cases its design is always controlled by a tradition of the rational pediment, i.e., of the Greek pediment, and it is important to properly understand the reason for the arrangements peculiar to the pediment.

Take the most noble of all, the Greek pediment (Fig. 388). Columns are completed and the entablature set; on each of

its four facades the monument is terminated by a cornice, that on the two longer sides receiving the guttere of the roof.

On the front and rear facades, the walls should be again crowned by triangular gables; the same (or nearly the same) cornice crowns obliquely those triangular parts, forming the complete pediment like a wall. And if mentally you connect by two planes the ears and ridge to the corresponding lines of the opposite pediment, you form a perfect prism with the intersecting ridge at its top.

Yet the edifice is not finished, for it still requires the roof, whose thickness must be stopped by a projection above the gables. This will be the cyma, that forms a part of the roof and not of the cornice.

Thus on this pediment –– and on all pediments –– there is no cyma on the horizontal cornice, since there is no roof on this cornice. There is only a cyma on raking cornices, but it is returned horizontally on the cornices of the lateral facades, where it becomes the gutter of the roof, either for the entire length of these lateral facades, or at the ends alone, when as on the Pantheon the water from the roof falls freely by a simple eave; then the lateral cornices are crowned by antefixas, that form the ends of the cover tiles, that separate the rows of tiles. In the example considered, the tiles, cover tiles and antefixas are of marble, but the arrangement remains the same for terra cotta.

Such is the initial composition of every pediment; a composition absolutely logical and pure. I cannot show you a more beautiful example than the angle of the pediment of the Parthenon (Fig. 389), borrowed from the restoration of M Loviot, who sought to restore the coloring –– a question left aside.

Later for facility of execution and clarity of effect, men were led to modify the last moulding of the cornice, always terminated by a flat fillet. The form of the cyma is also modified (Fig. 390), and the cornice is returned by passing from the horizontal to the raking by a vertical plane determined by the last fillet A. Also the upper line of the horizontal cornice stops at the point B, the intersection of the horizontal and raking fillets.

Such is the arrangement of all pediments, numerous examples

of which are to be seen in the most varied architectural motives and even in furniture. It is always the antique pediment with some changes of mouldings. Is it not instructive to show thus the fixedness for so many centuries, principles and traditions remaining unchangeable, because they were imposed by logic and truth? It is rare indeed that raking mouldings have been arranged successfully, that only stop at the ends o the gable. There seems to result an effect of sliding, always disagreeable. Also when there is not a projecting angle there is usually a horizontal return indicating that the gable rests on the horizontal courses of the wall (Fig. 391). I will cite several examples —— they are very numerous —— at S. Chapelle, Notre Dame, S. Laurent (Fig. 392), S. Eustache, all in the first theory; in the second are the secondary gabl of various churches, and that of S. Etienne-du-Mont (Fig. 393

Sometimes and particularly in the North, in Flanders, England and Germany, the gables terminate in steps; sometimes they take forms that apparently recall the roofs; such are th gables of the celebrated Church of Brou.

I have not exhausted all that might be said on roofs. Only remember always, that a roof is never too simple; the ignorant formula of admiration, that consists in saying that a ro is a forest of timbers, is in reality a criticism; today with iron the span may be made much greater, and frequently the roofs may henceforth be constructed with purlins and ridges, but without trusses by employing division walls. Appl cations are very varied, and there can be no general rules, except simplicity; I say again, that it is already sufficiently difficult to properly make a simple construction, and not complicate it at pleasure.

And when you make your plans of stories, think early of your roofs, for there is the punishment for all, who yield to the fashion of disjunction and irregularity.

As for the gable, when the roofs have pronounced inclinations, their decoration ordinarily consists of raking mouldin plain enough, but abutting at the two ends against a projecting motive forming a stop, as shown by Fig. 391.

## CHAPTER VI. FLOORS AND CEILINGS.

SUMMARY. –– Composition of floors. –– Wooden floors. –– Projecting beams. –– Artificial projections. –– Spans. –– Internal cornices. –– Various arrangementsof floors. –– Visible construction. –– Ornamental ceilings. –– Transition from wall to ceilings. –– Visible framework.

### Floors.

So far, walls, piers and roofs have been mentioned; we have seen that shelter forms the primary object of architecture. There are simple shelters and maghificent shelters; perhaps for a long time the architect had no other programme, and our civilization, that owes so much to architecture, had not foun in construction more extensive resources had yet civilization. With shelter existed the dwelling, the nomadic state was no longer the rule, and all needs of men in society could be satisfied.

But for that society, architecture desired more, it desired to bring together men by increasing the ground, and it created stories. This must have been boldness at the beginning, and who knows that if at first this novelty was not received with the fears aroused by every advance? It appears entirely simple today to live at 33 or even 66 ft. above the ground; these codditions of habitation permitting great cities are a victory of the art; by what means? By floors, vaults and stories.

Although floor (plancher) comes from planks(planches), this word does not designate the flooring. The floor is the entire structure of a horizontal division, supporting tiles or flooring, and which may be of iron or of wood, or again of mixed construction. Let us merely say, that iron is more andmore substituted for wood in the construction of floors.

But as the result of long historical use, from wood proceed the art of floors, and if very interesting experiments have been made where iron remains visible and by itself gives the appearance of the floor, it is to be recognized that the monumental expression of the floors and ceilings, with their rich and beautiful appearance, belongs to wooden architecture.

But my part is to discuss neither construction proper nor decoration. Before ceilings like that of Henry II at the

Louvre, the sole theory is to admire it. I rather have to show the influence and effect of floors on the architectural composition.

It is necessary to recall very briefly the principles controlling the construction of a floor.

Beneath the flooring or tiles —— the floor resting on the small strips of wood termed furring, and the tiles on a layer of gravel or of pulverized plaster —— must be a construction realizing a horizontal partition or artificial ground, for which is intended the construction of the floor.

Wooden Floors. —— Excepting the floors of Swiss chalets composed of joined timbers, between the structural beams for a floor are left spaces (Fig. 394). The floor is constructed of beams with sections according to their lengths and spaced about 14 ins. on centres. On these are placed thin jointed split oak boards, on which is cast a layer of plaster or mortar, which becomes the artificial ground, to receive flooring tiles, mosaic, etc.

The joints may remain visible, the surface of the boards being plastered, or dressed boards are used instead of splits; or a ceiling is placed below the joists, formed of laths nailed on the joints and plastered.

The complete floor is then subdivided as in Fig. 395. (The strips are here shown parallel to the beams, but are frequently perpendicular to them. A floor should be sufficiently strong for the strips to be laid in either direction). The thickness of such a floor cannot be much less than 16 ins.

But this arrangement with simple joists is rarely admissible. Commonly floors consist of main beams and joists, the beams resting on the solid parts of the construction, the floor being composed of beams E,E (Fig. 396), of headers C,C, and of ordinary joists. These timbers are in a plane at bottom and so present a plane ceiling.

But in floors of great span projecting girders must often be allowed, for their depths would exceed that proper for the depth of a floor. The architect may further produce a happy decorative effect by arranging these beams regularly and forming panels.

These projecting beams may be entirely below the joists (Fi 397), the joists may be visible or be plastered. Or the

joists may be tenoned into the beams (Fig. 398), only a part of the beam then showing below the joists, which are visible or plastered.

Either method will be adopted according to the space at command and the height of the story, the first being more monumental in appearance, but risking the effect of being crushed in a low story, so that floors of great beauty with single beams and joists have been built, that satisfy the primary condition of art, complete harmony of decoration with construction, notably the beautiful floor with visible beams and joists of the gallery of Cerfs at Fontainebleau, or the less known one of the City Hall of Beaugency (Fig. 399).

Yet you will also see magnificent ceilings whose relief is mere decoration and do not indicate the construction itself; such are compartments or panels of very varied combinations, often very rich. But in that case the floor must first be constructed more strongly, since it must support that suspended decoration. The total depth will then be increased by the height necessary for the attached panels. Then this combination is to be reserved for rich interiors of ample height

But this is also done in modest proportions in our houses by means of mouldings run in plaster. Therefore when you see panels on one of these ceilings as in Fig. 400, the ground B is the construction, the mouldings A are attached, and it would be an error to sink the grounds B,B, into the construction, in spite of their paneled appearance.

Floors of Iron. —— Today the use of iron has almost completely replaced the use of wood for floors, notably in important structures and houses. It has great advantages, being incombustible and does not rot, and affords all the stiffness desired; its strength can be computed with more certainty, and it permits spans not to be attained with wood.

Here again the joists receive the tiles or flooring. The joists are I beams spaced 2 to 2.5 ft. on centres; the filling is made in several ways, hollow tiles and plaster (Fig. 401), or plaster fragments and plaster (Fig. 402); to give solidity to the filling in the last case, the joists are connected by square rods E bent at each end, on which are laid small rough bars F, forming a sort of gridiron. The ceiling beneath is plastered.

Iron beams extend between the walls with anchors at each end or are framed similarly to wooden floors. Finally the beams may be visible beneath, either framed of two I beams (Fig. 403) held together by flat bands and bridging, or built girders with various shapes riveted together (Fig. 404). The girder then really forms an iron beam of I section, stronger than the rolled beam and composed of a web, four angles, and if necessary, two plates.

The beam may also be a box-girder (Fig. 405), when it is wider and has two webs.

Finally, as for wood, the beams may be placed upon or frame to the girder. The first case is entirely simple. Framing is done by angles riveted to the beam and bolted to the girder, and it is well to rest the end of the beam on an angle S (Fig. 406). In this figure the girder rises above the beams by the height of the upper angles, the framing then being better, but the beams may be raised up to the leg of t the angle (Fig. 407).

All elements of floors must be carefully calculated, which you will later learn to do. Now you know that an iron floor is actually an iron wall placed horizontally, supported by metal girders if necessary.

This metal construction sometines remains visible, but its possible effects are varied little, the beams then being plastered and receiving mouldings and applied ornaments.

As for the resources of applied ornamentation, what was said of the wooden floor equally applies to those of iron, bu if the decoration consists of panels not resulting from the construction, the thickness of the floor must comprise both beams and girders.

Iron floors are generally a little thinner than those of wood, but you will err little by indicating in a general design a depth of 12 to 16 ins. for the general floor of wood or iron, the depths required for the girders and applied decoration being taken extra.

In general, floors assume relatively limited spans, while an edifice such as the antique basilicas or certain churches, covered by a ceiling suspended from the framework of the roof may have very great spans; the Basilica of S. Paul-w-t-W has nearly 78.7 ft. clear span. For a wooden floor, a span of [illegible] to [illegible] ft., is already very great, being but a trifle greater [illegible] for wooden girders. In iron the beams may be made [illegible] almost indefinite, but then the girders must have enormous depths, partly to be arranged in gothic [illegible], and spans of iron floors of 31.5 or 39.4 ft., are already [illegible] in the construction of our monuments, than [illegible] used in our houses, because of the excessive depth required for the floors.

Thus the architect should know how to find for supporting its floors, points of support judiciously arranged, [illegible] use of foresight and ingenuity.

From the point of view of construction as well as the resulting architectural appearance, floors may be grouped in two classes, those with or without main girders.

Between walls near together, the floor of iron or wood [illegible] lathed and plastered, you have an actual horizontal frame of iron or wood between two surfaces, the upper being the floor [illegible] of our apartments.

Below this plaster ceiling are applied projecting mouldings around the room in the angle between the walls and ceiling as a cornice; all this is more or less decorative and [illegible].

There is here a very vicious instruction to be seen frequently in your sections, when you draw concave internal [illegible] into the depth of the floor (fig. [illegible]). This depth is determined by the construction and [illegible] it by a cornice, than to hollow out a wall to mould it. The correct indication is that given in Fig. 400.

It is not to be stated, that the internal cornice plays a part entirely different from the cornice of a facade, [illegible] also, may be seen very beautiful internal cornices. Some [illegible]

In old wooden floors without [illegible]

23.0 to 26.3 ft. is already very great being then a considerable length for wooden girders. In iron the spans may be much greater, almost indefinite, but then the girders have enormous depths, rarely to be arranged in public structures, and spans of iron floors of 32.8 or 39.4 ft. are almost extreme in the construction of our monuments, that cannot be re ized in our houses, because of the excessive depth required for the floors.

Thus the architect should know how to find for supporting his floors, points of support judiciously arranged, which may not interfere with use or injure the effect. Evidently a matter of foresight and ingenuity.

From the point of view of construction as well as of the resulting architectural appearance, floors may be placed in two classes, those with or without main girders.

Between walls near together, the floor of iron or wood consists of joists, and when these joists are filled between or lathed and plastered, you have an actual horizontal frame of iron or wood between two surfaces, the upper being the flooring and the lower the plastered ceiling. Such are the floors of our apartments.

Below this plaster ceiling are applied projecting mouldings extending around the room in the angle between the wall and ceiling as a cornice; all this is more or less decorated and is an added projection.

Then it is a very vicious indication to be seen frequently in your sections, when you draw concave internal cornices, whose section cuts into the depth of the floor (Fig. 408). This depth is determined by the construction and must be respected, and you should no more hollow out a floor to cover it by a cornice, than to hollow out a wall to mould it. The correct indication is that given in Fig. 400.

It is now to be stated, that the internal cornice plays a part entirely different from the cornice of a facade, and no longer calls for the same elements. It is very frequently merely a great cavetto, but which should always project and not be hollowed to injure the floor. At Versailles in particular, may be seen very beautiful internal cornices. Some beautiful examples are given in Figs. 409 to 413.

In old wooden floors without projecting girders, the con-

[illegible] remains visible, with the [illegible] from a decoration by their projection and [illegible] necessitate painting, as well as the spaces between them. [illegible] these floors without girders can cover only small limited spaces or small rooms, and therefore are not [illegible] [illegible] here.

As for floors with girders, they are used in two very different systems, but it is first necessary to take [illegible] the general construction of the floors.

Assume two parallel walls a considerable distance apart, say 26.4 ft. The method with joists is [illegible] impracticable, at least in wood, for each joist must be [illegible] [illegible] permitting the joists to have a span corresponding to their dimensions, of about 13.2 ft.; consequently to support the whole are required much stronger beams or girders; strength is concentrated, and the joists will be merely a filling.

But these girders can have the desired strength only on [illegible] [illegible] not have a greater depth without becoming uselessly heavy; [illegible] 24 to 30 ins. for the girders. Since the whole must present a plane surface above, only by projections below can be necessarily shown the different depths of the construction.

Every great floor is then a horizontal division with [illegible] projecting beneath it. It is somewhat analogous [illegible] and externally strengthened by buttresses.

[illegible] tion visible. The girders then project, the joists [illegible]

If the entire wooden framework be left visible, [illegible] the floors of our country; if the work be well executed with regular spacing, timbers properly squared, we obtain a floor with an architectural appearance, and with more [illegible] a little decoration, it will easily become [illegible] struction quite frequently remains visible, when the joists form a decoration by their projection and sometimes receive decorative painting, as well as the spaces between them. Naturally these floors without girders can cover only quite limited spaces or small rooms, and therefore are not motives for monumental compositions; elegance and grace are rather appropriate here.

As for floors with girders, they are used in two very different systems, but it is first necessary to take into account the general construction of the floors.

Assume two parallel walls a considerable distance apart, say 26.3 ft. The method with joists is here almost impossible, at least in wood, for each joist must be an actual beam, not to bend under its weight. Then is required a combination permitting the joists to have a span corresponding to their dimensions, of about 13.2 ft.; consequently to support the whole are required much stronger beams or girders; strength is concentrated, and the joists will be merely a filling.

But these girders can have the desired strength only on condition of having the depth, varying with the needs of the construction; about 14 to 16 ins. for the joists, which could not have a greater depth without becoming uselessly heavy; perhaps 24 to 33 ins. for the girders. Since the whole must present a plane surface above, only by projections below can be necessarily shown the different depths of the construction.

Every great floor is then a horizontal division with girders projecting beneath it. It is somewhat analogous, excepting in direction, to a great wall with plane internal surface and externally strengthened by buttresses.

Understanding this arrangement properly, the most natural design of these great floors consists in leaving the construction visible. The girders then project, the joists between girders are themselves visible or receive a plastered ceiling.

If the entire wooden framework be left visible, only arranged to satisfy the needs of the construction, we have the rustic floors of our country; if the work be well executed with regular spacing, timbers properly squared, we obtain a floor with an architectural appearance, and with some mouldings or a little decoration, it will easily become one of those beau-

tiful ceilings with visible woodwork, such as you see at the School, Museum Cluny, Fontainebleau, and around the court of the Invalides.

These beautiful ceilings have a great charm for the architect, even their truth. They are not only the expression of the construction, but the construction itself. Such is this charm, that one does not defend himself for imitating them by artificial means, and that even under iron beams are sometimes seen imitations of wooden joists, made by the plasterer. It may be said, that like hypocrisy, this is the homage rendered by vice to virtue.

But they cannot be varied, being necessarily composed of elements always the same, the girders with spacing fixed by the width of bays, the joists with dimensions and spaces scarcely varying. Even the decoration can differ only in detail and coloring. And since ceilings are an occasion of beautiful artistic combinations and great ornamental richness, it has been sought to introduce variety by elements no longer the construction of the floor, but by merely decorative combinations.

Yet between the floor of pure construction just mentioned and the purely decorated ceiling are several intermediate terms; elements of construction arranged for decoration and framed at distances determined to form large panels, still an expression of the construction, but of a construction designed for decoration (Fig. 414), and also floors with visible b beams, where the entire space between the beams, forms a decorative panel in carved wood, one of the most beautiful examples being the floor extending over the Library of the School of Fine Arts (Fig. 415).

Finally, a great number of admirable ceilings are purely decorative. I mean by these, that beneath the construction of the floor, or rather the projecting beams, special frames are suspended from this floor by bolts or other irons, serving to support attached cabinet work and sculptures. These ceilings are really great applied panels. Such is the ceiling already cited of the chamber of Henry II at the Louvre, (Fig. 421), the ceilings of Fontainebleau (Fig. 416), those of numerous churches, notably of Ara-Coeli (Fig. 417), S. Maria Maggiore (Fig. 418) and S. John )ateran; the ceilings of

Palace Doge of Venice, Palace Farnese (Fig. 419), Palace of Justice of Rouen (Fig. 420).

But you see that to permit these noble compositions requires so considerable depth, since then is necessary the entire depth of the construction at the most projecting part, adding [illegible]

Note well, that a ceiling requires vigorous decoration and powerful effects. When of great dimensions, its effect is always to be feared in flatness. A ceiling produces the effect [illegible] clearly indicating the stability of the construction. It is [illegible] you may dispose of sufficient depth -- yet without [illegible] proportions.

It always delicate study is the transition from wall to ceiling. Whether the wall be plane or have projections of columns, pilasters, etc., or isolated points of support, we [illegible] chief, an internal entablature, but the interior is in architecture, and in the beautiful works, you will easily recognize, that the architect has indeed desired to make [illegible]

Thus recalling that beautiful example of the chamber of Henry II (Fig. 421), you see there a frieze with rich cornice, that crowns the vertical walls, and which supports -- no long [illegible] ity the ceiling itself is the last part of the entablature, [illegible] ure were external.

I have reserved for this comparison the study of visible framework, although such may be roofs, by reason of the decorative element permitting them to be compared to ceilings. [illegible] framework, which should be simple and avoid a profusion of [illegible] Miniato of Florence (Fig. 422) and the Ca[illegible]

Palace Doge of Venice, Palace Farnese (Fig. 419), Palace of Justice of Rouen (Fig. 420).

But you see that to permit these noble compositions requires a considerable depth, since then is necessary the entire depth of the construction at the most projecting part, adding the entire thickness of the ornamental ceiling.

Note well, that a ceiling requires vigorous projections and powerful effects. When of grand dimensions, the effect always to be feared is flatness. A ceiling producing the effect of a great flat covering has an easily disagreeable appearance, whatever its decoration. Without the reality of beams clearly indicating the stability of the construction, it is at least necessary for the vigor of the projections and of hollows to present the appearance of that stability, and that you may dispose of sufficient depth -- yet without crushing the hall by the power of the ceiling. A matter of taste and proportion.

An always delicate study is the transition from wall to ceiling. Whether the wall be plane or have projections of columns, pilasters, etc., or isolated points of support, we always come to a last straight course and a sort of cornice, in brief, an internal entablature. But the interior is internal architecture, and in the beautiful works, you will easily recognize, that the architect has indeed desired to make something different from a facade.

Thus resuming that beautiful example of the chamber of Henry II (Fig. 421), you see there a frieze with rich consoles, that crowns the vertical walls, and which supports -- no longer a corona, but the first enclosure of the ceiling; in reality the ceiling itself is the last part of the entablature, substituted for what would be the cornice, if this architecture were external.

I have reserved for this comparison the study of visible framework, although such may be roofs, by reason of the decorative element permitting them to be compared to ceilings.

The only theory of these works is the arrangement of the framework, which should be simple and avoid a profusion of members, that here may easily become confusion. There are many beautiful examples, notably at Monreale (Fig. 422), S. Miniato of Florence (Fig. 423) and the Cathedral of Messina.

(Fig. 424). In mediaeval architecture, great vaults of wood were sometimes built; I can only cite some examples, like the Palace of Justice of Rouen, the celebrated great Hall of Westminster, or that of Hampton Court in England (Figs. 425, 426) and finally the chapel of our School.

As for iron floors, they are either covered and then treated with applied decoration, like those of the City Hall, and many of the Palace of Justice; their design does not sensibly differ from that of wooden ceilings or the girders and joists remain visible, and then a structural design will direct you; special theories on this subject cannot be given, since sturctural considerations here precede all others. Very meritorious attempts have been made in seeking a monumental expression for these floors; but if frequently very interesting for the tradesman, nothing has yet been produced, that can cause us to forget the beautiful wooden ceilings with their splendid artistic decorations -- particularly when a Paul Veronese depicts there the glory of Venice (Fig. 427).

# CHAPTER VII. VAULTS IN GENERAL.

SUMMARY. -- Equilibrium of Vaults. -- Their forces. -- Strength of Piers. -- Blans of vaulted edifices. -- Italian plans of vaulted edifices with iron tie-rods. -- Dangers of vaults. -- Methods of construction; stereometric vaults in cut stone; vaults of small materials; mediaeval vaults on independent arches. -- Thrusts and resistances. -- Construction in repose and in movement. -- Consideration of height, of elevation of stories, etc.

If I proposed to state everything comprised in this subject of vaults, volumes would not suffice. In the case of vaults, the genius of architects in a contest with the most formidable difficulties has secured the most splendid results. Everyone knows certain of these works, that habit alone prevents us from regarding as prodigies; vaults of palaces, bridges or cathedrals, domes resting on other vaults, etc. Nothing is more noble or beautiful, and nothing requires more knowledge.

I have explained the arch and the elementary vault, which is merely a deeper arch. You have learned the thrust of an arch and how it is neutralized, this resistance being easily ensured in a wall pierced by openings, but becomes far more doubtful when a vault no longer acts lengthwise the wall but transversely, tending to overthrow it (Fig. 428). If the vault are also elevated and act at the top of the walls like a powerful lever arm, stability can only be obtained by ingenious arrangements and the combination of abutments.

When result are concerned, the ignorant constructor is placed between two dangers; too bold or rather rash, he exposes it to destruction -- there are numerous examples of vaults falling or overturning their points of support even during erection; too timtd, he will seek safety in excessive thickness of piers and walls and useless buttresses, and will burden his edifice with costly and encumbering additions, even if the excess of precautions does not in its turn destroy the stability, as sometimes too strongly in a weak wall, it is pushed over inward to prevent it from falling outward.

In brief, every vault is in conditional equilibrium; its permanent action would destroy the edifice if resistance

equally permanent did neutralize the former. These resistances may be of two kinds; external, by extra thickness of walls or piers, buttresses and flying buttresses, internal, by tension, the spreading apart of the walls. Without entering into the theory of the stability of vaults, later observed in the study of construction, I can state that the primary condition of that stability is, that the static resultant of the action of the vault, the curve R,R, found by a careful drawin must always remain within the section of the vault and of its abutments(Fig. 429). This curve has its part nearest the intrados at the crown, becomes sensibly more distant to the angle of 30° to a horizontal, continying obliquely within the abutment. The stability of the vault is regarded as doubtful if the foot of this oblique line falls outside the middle third of the thickness of the wall.

The curve is a resultant of several forces, of thrusts and of resisting loads, the thrust being only a form of load. Thus the lighter the vault, the smaller its thrust, and the heavier the piers, they are more resistant. The lightness of the vaults results from their section, that should not exhibit useless or badly arranged thickness, from materials like light stone, bricks rather hollow thah solid, or like the Romans, of pumice stone with minimum density; finally, by recesses that leave the vault the required thickness in the essential parts, composing important surfaces of simple and thinner compartments.

As for the weight of the piers, it results from their mass, the density of the materials, and also the load at the top. Thus the same vault, that would require very thick walls for a single hall A (Fig. 430), would find sufficient resistance by thinner walls B, if these walls are loaded by one or more stories; and reciprocally, the removal of an upper story migh cause the wall to fall, far from relieving a vaulted ground story.

As already seen for arches, the thrust of a vault is greater as it becomes flatter, apointed vault or one elliptically vertical, or forming a catenary (natural curve of a chain inverted ) with span less than height, thrusts comparatively li tle; on the contrary, segmental vaults thrust strongly, and the maximum thrust is found in the radially jointed ceiling,

a vault analogous to the jointed platband as an arch.

So many different cases occur -- form and composition of the vault, proportion of height to span, height of abutments, superposed loads, etc. -- that it is impossible to give general rules or even empirical proportions. Here are some examples of proportions between the thickness of walls and the spans of well known vaulted halls; these examples are taken from continuous tunnel vaults, or domes without the load of upper stories. (For Table see page 257½.)

*Note. that the results to be deduced from this Table are n absolute, not merely by reason of differences in heights, lo etc., but also because the external walls are most frequently accompanied by ornamental projections, that contribute to the resistance. These data must be taken as quite approximate and under all reserves.*

These thicknesses of walls are all different from those adapted to floors and roofs, however they may be. Hence a vaulted plan should be recognized at the first glance. Examine the plan of the ground story of the Louvre (Fig. 431), or those of Versailles, Palace of justice of Paris, most Roman edifices, as Palace Corsini (Fig. 432), those of Genoa, Florence, and finally those of our churches and cathedrals, etc. Those are vaulted plans, deriving from the vaults their proportions and appearance.

Yet you will find in the books plans astonishing you by their lightness, when the sections exhibit vaults. Very frequently and particularly in Italian architecture, the thrusts of vaults are neutralized by iron ties, the piers only supporting the vertical loads, and can be made light; but by a vexatious inaccuracy, the engravings of these edifices do not generally exhibit that necessary element, and the representation becomes deceptive by insufficiency.

Many justly celebrated compositions, notably in Tuscany, owe to their use of iron ties the condition of their elegance and economy.

Yet absolute theorists have proscribed the use of ties for vaults, and you will again hear these anathemas. The science of the architect, they say, must combine the elements of stability sufficient in themselves without resorting to expedients, that are even the negation of the principle of the vaul

| Monuments. | Materials of Vaults. | Diameter of Vault. | Thickness of wall at Springing. | Bearing of diameter on wall. |
|---|---|---|---|---|
| | | About. | About. | |
| Pantheon of Rome(spherical vault, hollow walls). | Bricks and concrete. | 146'. | 22.3' | 21.5' |
| Great circular hall of Baths of Caracalla, do., do. | do. | 115. | 21.3 | 15.3 |
| Basilica of Constantine (tunnel vault). | do. | 79. | 13.8 | 18.8 |
| Temple of Venus and Rome(tunnel vault). | do. | 66.5 | 9.8 | 22.0 |
| S. Sophia of Constantinople, second story of narthex(tunnel vault). | Bricks. | 28.2 | 7.2 | 13.1 |
| Lantern in cloister vault of S. Michel of Pavia. | do. | 31.5 | 3.6 | 28.6 |
| Cathedral of Florence ( octagonal dome ).[1] | do. | 138. | 17.0 | 26.5 |
| S. Peter of Rome, dome meridian through arch | do. | 137. | 12.2 | 36.0 |
| Do., through panel. | do. | 137. | 9.2 | 47.5 |
| Do., nave ( abutted tunnel vault ). | do. | 91.5 | 11.8 | 25.3 |
| Dome of Invalides | Stone. | 85.4 | 13.2 | 21.3 |
| Waiting hall, Palace of Justice, (tunnel vault) through transverse arches. | Stone. | 41.0 | 6.3(varies) | 21.6 |
| Do., do., through panels. | Brick. | 44.7 | 3.3 | 44.6 |
| Gallery Marchande. | Stone. | 24.3 | 5.9 | 13.5 |
| Palace Luxemburg, grand stairway, | Stone. | 26.2 | 5.9 | 14.6 |

(1. Note. This dome is hooped by iron bands).

This is doubtless very brave; I admire as much as any one the vaults of the Romans supported by their immovable piers, but I also admire the marvellous Loggia dei Lanzi at Florence, (Fig. 308), where some thin bars of iron have permitted such elegant and delicate proportions.

In any case, note well that the vault is a work never free from difficulties. The architect is certain to treat a floor or ceiling with honor, especially today, and where easy construction is sought, the floor -- plane construction -- is increasingly substituted for the vault; even bridges commonly have simple floors, when formerly they were beautiful vaults in stone. Well, it is a loss, for the vault has a superb beauty, a character of durability and grandeur, that nothing may replace. Who will then dare to think of our cathedrals, arches of triumph, palace vestibules and porticos, without the vaults that are their nobility? Even from the point of view of simple utility, the vault shelters better, protects from weather, and if well constructed at the beginning, resists time better than any other mode of covering our edifices. It lends itself to the most magnificent decorations and affords opportunity for incomparable masterpieces.

Then I insist, that from the point of view of composition, there are capital differences between the arch and vault, important to point out at first.

The arch most frequently exerts its thrust lengthwise a wal and is ordinarily abutted by it; if it tends to produce tension in the wall, it does not endanger its own overthrow. On the contrary, the vault often thrusts against the wall transversely, tending to push it over outwards. Generally therefore, the vault is more dangerous than the arch.

On the other hand, the arch is nearly always loaded by the construction above it, but on the contrary it is sought to not load vaults, or to load them as little as possible. If they take the place of floors between the stories, or if buil beneath terraces, they evidently support a load increasing the overturning action of their thrust; this load at least is reduced to a minimum. And as for vaults with the function of merely closing the upper part of an edifice, like vaults of churches, it is necessary to take good care, that they bear nothing but themselves; hence it would be a great fault to

make them support the framework of roofs.

Remember that vaults are a magnificent element of architecture, but their use demands science and prudence; that the architect should firmly refuse to construct vaults when his composition, and particularly his plan, does not permit this.

Too frequently, for example in churches, everything is carried, not to wise economy but to imprudent parsimony; walls are too thin, buttresses are farcical, and yet vaults are desired just the same, because the celebrated churches are vaul ed. What happens? Destruction, more frequently than you think-

The vault is very dangerous in the hands of ignorant men, and I cannot too strongly advise you to study with the greatest care the methods of verification taught in the course of construction, while recalling to you, that before verifying, it is necessary to conceive, and your composition alone will permit easy and safe vaults, or that otherwise you should make it a principle to avoid them.

Independently of questions of the forms of vaults, to be mentioned later, it is first necessary to distinguish three systems of construction, applicable to the various forms of vaults, and that profoundly modify their action and appearanc

There are vaults in cut stone, vaults in rubble or small materials, and mediaeval vaults supported by arches.

The cut stone or stereometric vault with a grand monumental appearance is that most frequently seen in our modern French architecture. Its beauty is primarily in its regular jointing, its sculptured decoration and even the stone. Examples abound, all noble and magnificent; it suffices to cite the hall of the Caryatids at the Louvre (Fig. 433), the middle aisles of Val-de-Grace, the Pantheon and the Arch of the Star.

But these vaults are heavy, even with the use of stone of low density. Further the voussoirs are in contact only on the joint planes, not combined together as in rubble, have no stability together; the vault is then only maintained by the cutting, by the science of stereometry, and for the same span and curvature, this vault in cut stone thrusts most strongly. Then to it must be opposed energetic resistance by the stability of the walls or piers receiving it.

Rubble vaults are those of the great Roman monuments repre-

sented in detail in the examples taken from the work of M. Choisy, L'Art de Batir chez les Romains (Figs. 434, 435, 436), such as the Pantheon, the Baths and the Basilica of Constantine. There the skeleton is accented by the use of bricks along the directrices and generatrices of cylindrical vaults, meridians and parallels of spherical vaults, with ingenious combinations of discharging arches combined in the vault itself. Brick arches (the primary idea of the ribbed vaults of the middle ages) determine the essential parts of the construction (Fig. 437). The spaces between the skeleton are fil ed by rubble, a sort of concrete, whose excellent mortar connects spalls and pieces of stone, preferably of very light pumice stone, found abundantly in volcanic regions. The use of these small materials set in a bed of mortar makes the whole a sort of monolith, whose thrust is nothing -- note thi well -- unless it breaks. I shall return soon to the consideration of thrusts.

To these vaults in small materials may be added the brick vaults, like all modern vaults of Italy and Southern France. Both have as a characteristic the absence of vaulting, seeking monolithic construction with the necessity of plastering, except in the rare cases when the vaults appear with intrados of visible bricks. Unfortunately, it must be said, that this wise construction of masonry vaults was not that of the 17th century, and the beautiful vaults of Versailles and others of the same time are built of wood, ribs and laths with a covering of plaster. Thus they are much less durable and are subject to all causes of precarious existence, that result from the use of wood.

I shall later speak of the decoration of the different vaul

The vaults of the middle ages -- when no longer merely the antique vault as in Latin architecture and even Romanesque at its beginning -- mediaeval vaults are a complex conception, or rather are less a conception than a final result of successive experiments, whose historical trace may be followed, and that ended in a complete system, which one might believe, and sometimes has believed to be a creation in all its parts. Notably its genesis may be seen in the churches of Angers.

In my turn, to show you this evolution, I am compelled to lead you along a rather long and winding path.

You know that to construct a vault -- whether of a bridge

or a hall -- there is first required a centering, producing temporarily in wood the surfaces accurately adjoining all parts of the intrados. This surface is composed of planks or timbers supported by trussed centres of carpentry. This work in carpentry is often complicated and requires much ingenuity The trusses comprise the segments or centres proper, the posts, beams, ties, struts, etc. (Fig. 438).

Assuming now that the segments or true centres, placed beneath the vault where support is particularly required, to be in a manner petrified, when these centres become arches and then support the vault, as they are supported by the centering. Mediaeval vaults may be defined as vaults composed of stone arches supporting compartments of small materials.

The mediaeval vault then borrows from the Roman vault the conception of the skeleton and the filling; from the cut stone vault, it borrows the practice of stonecutting. Its original character is then in the projection of the skeleton, that is buried in the mass of the Roman vault, and in the combined use of these two elements; it has the filling and the jointed cut stone. Its thrusts are greater than those of the Roman vault, but less than those of the stereometric vaul Its character and appearance are primarily in the arrangement of its arches or ribs, that finally become very complicated combinations, although very elegant and ingenious. In the architecture of these vaults, the ribs are the key of the study.

I return to the thrusts of the vaults, not to teach you how to calculate them, that being the domain of the course on construction, but to show you how to provide for them in the composition. I cannot avoid some repetitions, but the importance of the subject will excuse them. Then entering into the questions of application, it is indeed necessary, that the composition renders possible the application of the rules of composition, for to compose is to foresee. If you divide your personality in thought, the composer foresees and ensures the constructability of his conception, and then the constructor verifies the stability, omits or adds to the essential elements, or even in that case, if it be necessary to seek a new arrangement, the composer will seek it -- perhaps profiting by the lesson.

Why does a vault thrust? Because it breaks; for no deform-

ation is no thrust. Assume that a monolithic vault be so homogeneous, that the adherence of its parts can be compared to molecular cohesion it will rest on the walls as a covering, and will exert no thrust. That is not a fiction, for at Ravenna is a circular edifice, the Tomb of Theodoric (Fig. 439), covered by a single stone cut in form of a dome; this is merely a cover and not a vault.

The vault thrusts by reason of the mobility of its elements.

Every thrust of a vault is a multiple action of stresses no parallel; these stresses form a resultant, which neither is nor can be horizontal or vertical. It is more or less oblique, and hence on meeting the wall or abutment, it is decomposed into two forces, one vertical and the other horizontal. The vertical force loads the wall, the horizontal force thrusts against it. If the wall be sufficiently resistant to resist overthrow, it also opposes all deformation of the vault, but if there be the least pertial displacement of the wall, there results a deformation of the vault or reciprocally; cracks follow the joints in cut stone vaults, irregular cracks occur in concrete vaults.

I pass over the disorder produced in a vault by the reciprocal action of its elements if the sections are badly designed. This is a very important point, that depends on the construction and not on the design.

This is to be well understood, that while the wall, colonnade, floor, all heretofore examined, are generally elements of construction at rest, the vault is an element of construction in movement. For static equilibrium is here substituted dynamic equilibrium, and the immobility of the construction will be obtained only if this movement be not suppressed but prevented by a sufficient resistance. This resistance will be primarily supplied by the plan, but not the plan alone.

Take some examples. You wish to build a vaulted hall with tunnel vault of a given span. You find somewhere a hall of precisely that width, same centering and jointing. You conclude that by giving your walls the thickness found in walls standing for two or three centuries, you will be free from all fears. Perhaps your vault falls.

If your model is of low height (Fig. 440), and your hall is very high, the resultant R of the stresses, that do not leave the section of the wall of your model will leave it in yours.

If your model belongs to a ground story below several stories, the vertical load of the walls there is considerable, and consequently the resistance of the walls; if your wall is in an edifice with merely a ground story, the resistance R'. will become insufficient (Fig. 428).

If your model be vaulted with light stone and your hall wit heavy stone; if the walls of your model are of heavy stone and yours of light stone; so many reasons again render insufficient the thickness sufficing for your model.

And it will be another matter again, if your vault be segmental instead of being semicircular or pointed, or if it be of cut stone instead of concrete.

All that may be calculated and verified, but already in laying out the plan, in the composition, all this should be foreseen, so that the final verification of the stability may hav nothing to act upon except slight changes.

This once more shows how foresight is the composition of the plan, and how this composition is at first entirely provisional, and can become definite only after the study of the entirety, a study peculiarly laborious in case of vaulted edifices.

## CHAPTER VIII. VAULTS IN GENERAL. CONTINUED.

SUMMARY. -- Direction of resistances; study of points of support. -- Vaults with thrust uniformly distributed. -- Vaul with concentrated thrusts. -- Lightness of vaults. -- Roman vaults. -- Materials. -- Coffers. -- Roman vaults of cut ston Nimes, Arles, Syria. -- Coffers in stone vaults. -- Projection of vaults. -- Relations of construction and decoration. -- Lighting vaults. -- Vaults independent of walls. -- Construction of vaults should be varied.

If the intensity of the thrusts can be determined at once and consequently the thickness of the walls to resist them, then in turn may be found their direction with certainty, as well as the corresponding direction of the points of support.

From this point of view, I shall divide vaults into two groups.

Vaults with thrusts uniformly distributed.

Vaults with concentrated thrusts.

The former are first tunnel vaults, then its special case of the cloister vault, the annular, the spherical, and that on a polygonal plan, which is merely a cloister vault.

The latter result from intersection of vaults; cross vault, vault with penetrations, and vaults on pendentives.

To uniform thrust must be opposed uniform resistance, so that tunnel and spherical vaults require walls of uniform thickness. Thus the Nympheum at Nimes (Fig. 441), whose vault is composed of a series of adjacent arches, has thick and homogeneous walls for their entire length. On the contrary, see the plan of S. Front of Perigueux (Fig. 442), whose vaults on pendentives are separated by wide transverse arches, and actually transmit all thrusts to definite points on the four diagonals of each dome. It is impossible to conceive a plan showing the construction better; the resistance is firmly established, the covering parts are relatively thin, everything has its place, and it may be said of this construction what was said of antique architecture; it is so, since it could not be otherwise.

No greater praise could be given to an architectural work. Also see the plans of the middle aisles of the Cathedrals of Alby (Figs. 443, 444,) and of Noyon (Figs. 445, 446), cited

from the same point of view.

From the preceding results a dominant idea; the perpetual contest of architecture with the dangers of the vault. Combinations have just been mentioned, which seek this aim by means of resistances of piers or walls. The counterpart consists in giving vaults the greatest lightness possible. Roman vaults are very instructive in this respect.

To properly understand such efforts made by architects in antiquity, and to fully prove the identity of methods of construction and of architectural forms, we shall examine the work in two entirely different countries, not in climate, but in the nature of the materials offered by the ground, in Rome and in southern France.

At Rome and in its vicinity the ground is volcanic; there are found very light tufa and pumice stone lighter than water, rough for adhesion of mortar; pozzulana is also found and mixed with lime to form the excellent mortar called Roman cement. Limestone is quite rare in that region.

Provence is essentially a limestone country, cut stone is in common use, even for very modest structures. Light materials are wanting. Mortar is excellent, but sand must be taken from the Rhone or its branches, less easily than today.

These differences being stated, what has been the solution of the same problem in both places?

Great vaults at Rome are of small materials. Take a rectangular hall with tunnel vault, like the side aisles of the Basilica of Constantine or Temple of Peace. The architect erects a wooden centering, and on its trusses are laid jointed timbers, generatrices of the cylinder (Fig. 447).

On this is simply spread and tamped concrete composed of light stones and mortar. But he desires still greater lightness, and the natural means is to lighten the vault by recesses. Assume that wooden boxes are regularly placed on the cylindrical centering at distances according to the dimensions of the bricks in use; these intervals are filled with bricks forming actual brick arches in the direction of the directrix of the cylinder, also in the direction of the generatrix, by bands of bricks. On each box may be placed another. Then the rubble or concrete is applied. After a certain time, when the mortar has set, the centering is removed and the boxes

also. You then find recesses in the vault, the counterpart of the boxes placed on the centering. These are coffers, whose name recalls the boxes mentioned, and were called lacunaria by the Romans, as explained in M. Choisy's Art de Batir chez les Romains, that I recommend you to study, and from whi is taken Fig. 448, representing the construction with ribs an coffers of the vaults of the Basilica of Constantine.

The coffer is then not a fanciful decoration, but is construction increasing the good appearance and elegance of the vault by varying it in so many ways. The coffer in the stone vault is merely an imitation of the vault of small materials.

Let us see what has been done in Provence for vaults in cut stone.

The Nympheum of Nimes has already been cited. The tunnel vault is composed of a series of deep arches supporting in rebates fillings, that are only slabs (Fig. 449). This again reduces weight, but in a single direction; it may be said to be a series of tunnel vaults alternately thick and thin.

At the Amphitheatre of Arles (Fig. 450) is a quite analogous arrangement, but more clearly arranged. A series of strong arches are separated by regular distances less than the length of a slab. This slab is horizontal and forms the floor of an upper gallery. The two systems then have the same longitudinal section, but the transverse sections are very different, as may be seen by the sketches. I can also cite certain Syrian churches of early construction, like the Basilica of Tafka, whose vaults are concreted like those of the Nympheum of Nimes.

As for vaults of stone with coffers, it must be recognized that this is not the result of construction, and that there may only be seen an imitation of the true coffers of vaults in small materials. In a vault of cut stone, jointed in regular courses as a tunnel vault left visible, the coffer can scarcely be treated except as a sunken ornament; the construction not being based on taking into account the coffer, or rather the coffer not being here the skeleton of the vault, it is necessary for the vault to have its required section outside the coffers, thus being necessary to ensure an excess of thickness, the coffer scarcely counting for the stability.

We are far from the rational theory of great stone ceilings

with strong supporting parts and their compartments. It would be extremely interesting to study in stone a vault with coffers forming a real skeleton, one would then have true arches with their transverse connections, a skeleton complete in itself and remaining open if desired; thin slabs or small materials forming the ground of the compartments. This would be the idea of the ceiling of the Temple of Mars the Avenger applied to vaults. —— But in other forms this would be the system of construction of vaults of the middle ages, inte secting ribs supporting the vault, coffer construction instea of coffer decoration.

For the vault in cut stone, the rational decoration is not the compartment or sunk coffer, in spite of the very beautiful examples. What is satisfactory is decoration by projecting compartments (Fig. 457). The vault has everywhere the desired thickness, and nothing prevents, that where mouldings should enclose compartments, a row of voussoirs from having an extra thickness and projecting from the intrados. It is a mere question of stone, but for this the decorative arrangement must be decided in advance, which is rare.

In a general way, it may be said that vaults in cut stone do not attain all the beauty of which they are capable, unless their decoration and construction are intimately connected. This forms for me the great charm of the vaults of the middle ages, either simple as in the 13th century, or refined as at S. Eustache. Unfortunately most vaults in cut stone are decorated by compositions afterwards, and sometimes the jointing is singularly opposed to the decoration.

Nothing is more contrary to actual facts and the eternal principle of art.

Construction and decoration are but one thing, which is architecture. When I speak of vaults, can I separate in that theory these two ideas? Is the coffer of Roman vaults construction alone or decoration alone? Are the ribs of mediaeval vaults construction only or decoration only? Each of these

ideas would be incomplete without the other. When once constructed, these vaults may be said to be decorated. And nowhere is that more apparent than in the vaults of the middle ages. We find these vaults very rich in effect, ingenious and attractive, and the decorative purpose certainly is manifested in them, particularly in the 14th and 15th centuries. But it is decoration by construction, by the ribs and various arches, i.e., the construction itself; construction designed for the two purposes of stability and of ornamental appearance. When finished, what remains to be done in the decoration? Nothing, for on the removal of the centering, the vault appears sufficiently decorated by its structural elements. If something more is to be added, this is only to paint it, i.e., to decorate it sometimes, more frequently to spoil it.

This general explanation of the architecture of vaults also requires two essential considerations, before passing to the study of each vault in particular. Vaults should in general be lighted directly. We sometimes see in restorations of antique monuments and in Italian architecture vaults above light openings and without any direct light, and even in Paris may be cited a very beautiful example, the Gallery of Apollo. Such vaults risk being dark, at least with us, and it appears to me difficult to risk at Paris the magnificent cloister vaults of Palace Pitti in Florence. The Gallery of Apollo is exceptionally lighted by its situation, and it is not well t that it is quite segmental. But when one has a semicircular section like the waiting hall of the Palace of Justice, S. S Sulpice, etc., the necessity for lighting is evidently imposed on the architect. As for the lighting of cross vaults, pendentives etc., we shall return to them in speaking of vaults in particular.

The other consideration to be explained, the more since you very frequently commit grave faults therein, is that your vaults should be independent from the rest of the construction Excepting the imposts, every stone common to walls and vaults will be exposed to rupture. Thus to make myself clearly understood, I go directly to the aim of my demonstration and say reserve the construction of your vaults to later, and erect them after your edifices are built.

That may surprise you after speaking to you so frequently

of solidity and of connection between the different parts of a structure, and I must explain.

It was previously stated, that the vault is an element of construction in movement. This definition is given in opposition to walls, colonnades, etc., that form construction in repose. I might say, never connect together movement and repose, but this would be a bit of metaphysics.

Then assune that in a ground story has been erected a vault in cut stone at the same time as the construction of the wall combined with that construction by as many bonds and through stones aspossible, What will happen? Every wall settles vertically and every vault horizontally. While the stone common to both is displaced vertically by the settlement of the wall it tends to be displaced horizontally by the settlement of the vault, which produces rupture. The imposts alone ( Fig. 452) are subjected by the wall and the vault to a nearly vertical movement downward. Besides, the impost cannot belong to both wall and vault. Hence you should erect the walls including the imposts, reserving the vaults.

There are other reasons for this. If your vaults are built before the upper stories are erected, the abutments of the vaults are not loaded, and the centering cannot be removed without risking the overthrow of thw walls by the thrust of the vaults. Further, if the vaults are built at the same time as the walls, they will serve as scaffolds and to receive materials -- whatever you do -- and they will be overloaded and destroyed. Finally, the vaults will be constructed before the building is roofed and will receive rain and snow to the great injury of stone and mortar.

The conclusion is that vaults should never be built before the building has received its roof. The design must then permit the construction of the vaults to be reserved in building the walls; I desired to state this in saying, that the vaults must be independent of the rest of the construction. Then such was the custom in the epochs when vaults were most skilfully employed. Thus at Fontainebleau, the great festal hall termed gallery of Henry II was first designed to be vaulted; the imposts are still visible, but the vault was not built, a ceiling being preferred for the hall, which could be done without demolition. So to make myself understood by a simple

example, I clearly indicate that if you have a tunnel vault and the end of this vault be closed by a wall, this wall should ignore the abutting of the vault, between the vault and the wall being a single continuous and semicircular joint

## CHAPTER IX. DECORATION OF VAULTS.

SUMMARY. -- Respect for the form of the vault. -- Panels -- Painting. -- Decorative painting. -- Fresco. -- Renaissanc paintings. -- Modern paintings.

A word now on the decoration of vaults in general. It will be very different from that of ceilings. For ceilings the motives call for accented projections a robust appearance of the construction, variety in depths of the compartments, always to correct the disagreeable and disquieting impression produced by a great horizontal plane, reassuring the observer by accenting the energy by strong reliefs.

The contrary is true for the vault, for its form is reassuring, and is further flexible and agreeable in appearance. The decoration should not deform it, and no applied decoratio should be sought, whose heavy appearance would cause anxiety. Examine the vaults richest in decoration, in stone notably those of Church Val-de-Grace, with applied ornament those of the Gallery of Apollo; the panels, mouldings and everything has slight projection, and you perceive everywhere the harmonious unity of the cylindrical vault, that nothing deforms. Note also that these decorations project, for I insist on that, which cannot be otherwise; you then commit a grave fault by indicating sunken compartments in a vault, which requires an unequal and impossible construction (Fig. 453); the decoration should consist in applied projections as shown by Fig. 451, so that the ground of the compartment may be the vault itself.

We frequently see your sections of tunnel vaults given as in the sketch (Fig. 454), which is simply impossible, requiring an enormous mass to be suspended from the vault. Observe beautiful models and you will abandon this vicious indication, bad in construction (I cannot even indicate the jointing in the sketch), and whose effect -- if execution were possible -- would be perfectly disagreeable.

I shall not treat of decoration derived from the construction itself, having cited to you on that subject the vaults of the middle ages. Certainly for vaults will be found there the most complete identity of construction and decoration.

A mode of decoration very appropriate for vaults is paint-

ing. Much more than the ceiling, the vault offers an admirable field for painting presented normally to the eye of the observer; to see the painting of vaults, no curvature is risked, and the perspective is easily satisfied. But there are two species of paihting, that purely decorative and the painting of subjects. Let us take the first.

At least for us, it is of Greco-Roman origin. The vault of small materials requires plastering in order to not remai rough like a cellar vault. This plastering originates stuccos and paintings of vaults; another example of the effect of construction on decoration.

Stucco -- which it is unnecessary to understand in its actual sense -- was a coating of lime mixed with marble dust, and while still fresh, this plaster was modeled in delicate and spirited sculptures, that owed to this improvisation an exquisite freshness. Our casts in carton-pierre or staff cannot give its idea, for it is a lost art, to be profoundly regretted. Scarcely except at Fontainebleau, a monument of Italian execution, are found near examples of this beautiful art of decoration in stucco, notably on the vault of the chapel.

But most frequently the decoration of this plastering consisted of paintings, the process being fresco or painting on the fresh plaster. While the plaster is still fresh (fresco) must it be painted rapidly and without retouching, in a sort of water colors. The motives are designed in advance by means of cartoons, sketched with spirit and painted in a few hours. No mode of painting has the artistic appearance of fresco, with its charm of freedom and of execution both rapid and studied. Nothing resembles it less than our rather mechanical decorations with stiff outlines and fastidious regularity.

By this means Grecian art painted on vaults ornamental compositions, that leave to the vault all its curvature, and move in a charming fancy. Such are the paintings of Pompeii and of Herculaneum, and such must have been especially those of the Golden House of Nero and of the Baths of Titus, known to Raphael, the starting point of those exquisite paintings of the Renaissance, that so far excelled their models, the loggias of the Vatican already shown to you and the vaults of Villa Madama (Fig. 455). In Italy are very numerous examples in palaces and villas, as at Palazzo del Te at Mantua, in the celebrated gallery of the Carracci in Palazzo Farnese (Fig. [illegible]), Villa of Pope Julius II at Caprarola (Fig. 449), Villa etc., and the library of the Vatican. The unfortunately an art, few examples of which can be indicated here, that we have no equivalent, except in Constantinople.

But the Renaissance went farther as you know, and it d [illegible] It is probable that antiquity was acquainted in a certain manner with these decorations: the mosaics of the Byzantine epoch owe to a tradition of a more ancient art. Between the mosaics and the paintings of the age of Pericles must be adequate difference as in sculpture and architecture. The as they have come to us, those Byzantine decorat and hieratic, have a grand style and character; they usually extend on the walls, yet we see them in even the vaults, almost always on spherical vaults, domes apses. Those of Ravenna and of S. Mark give us an idea what we should see -- still under the Turkish whitewash -- porches of S. Sophia of Constantinople. Among the most ful are those of Monreale in Sicily, perhaps equal [illegible]

I will not here discuss the painting, but I desire a give you an idea of their composition by a general vi [illegible] (Fig. 498). But there is really n imagery; this room is used without any thought of ar I will show later the [illegible] directing the religious ing of this ancient time, with isolated figures on a and usually golden ground, with neither linear nor perspective, and not painting with all its means. Pict composition appears with the Renaissance among all primitive, so [illegible] for architecture and sculpt [illegible] in short as [illegible] the [illegible] of [illegible] (Fig. 460, 461), it one who sees in [illegible] with Raphael and Michelangelo, the Renaissance [illegible] with the frescoes.

I do not have to speak of painting [illegible] in its relations with architecture. What shall I say [illegible] of the Sistine Chapel? Great [illegible] in palaces and villas, as at Palace del Te at Mantua, in the celebrated gallery of the Carrachi in Palace Farnese (Fig. 456), Villa of Pope Julius II at Caprarola (Fig. 457), Villa Pia and the Library of the Vatican. But unfortunately it is an art, few examples of which can be indicated here, for we have no equivalent, except at Fontainebleau.

But the Renaissance went farther as you know, and it decorated vaults by historical or allegorical paintings. It is probable that antiquity was acquainted in a certain measure with these decorations; the mosaics of the Byzantine epoch must be a tradition of a more ancient art. Between these mosaics and the paintings of the age of Pericles must be a considerable dirrerence as in sculpture and architecture. Such as they have come to us, those Byzantine decorations, stiff and hieratic, have a grand style and character. They particularly extend on the walls, yet we see numerous examples on the vaults, almost always on spherical vaults, pendentives or apses. Those of Ravenna and of S. Mark give us an idea of what [illegible] should be -- still under the Turkish whitewash -- the mosaics of S. Sophia of Constantinople. Among the most beautiful are those of Monreale in Sicily, perhaps especially those of the Chapel Palatine of Palermo; it is difficult to give an idea without the coloring, but I desire at least to have you judge of their composition by a general view of the last chapel (Figs. 458, 459). But there is really only an imagery. This word is used without any thought of criticism; I will show later the thought directing the religious painting of this ancient time, with isolated figures on a uniform and usually golden ground, with neither linear nor aerial perspective, and not painting with all its means. Picturesque composition appears with the Rehaissance among artists termed primitive, so respectful for architecture and careful for proportion and harmony, in brief so disinterested, as shown by the admirable paintings of Assisi (Figs. 460, 461), it develops and attains its climax with Raphael and Michelangelo, its greatest splendor with the Venetians.

I do not have to speak of painting otherwise than in its relations with architecture. What shall I say of the vaults of the Sistine Chapel? Great sorrow is silent, says the poet. Great admiration likewise. The admirable sculptor--Michel-

angelo -- became a painter and again excelled in the frescos of the vault, attaining absolute perfection, and as an artist places himself beside Phidias, whom he surpasses morally by the entire sublimity of his thought; There are emotions, that cannot be analyzed -- make a pilgrimage to the Sistine Chapel, seeking neither model nor inspiration, save for a man in twenty centuries, a paragon, for these are inaccessible heights, and whoever attempts to ascend them falls midway crushed!

Return to architecture in this decoration of vaults. The masterpieces of this kind have in common, that the painting does not conceal the vault nor destroy its form. The panels in relief or painted represent possible openings in the vault, in which it is possible to perceive a subject -- I do not wish to use the word painting. -- It is for the architect to limit the part of the painter, to arrange the compartments of his vault so that it remains possible and satisfactory, if the parts were open instead of pictures, for the painting represents distances and the opening in the vault. I may here cite a colossal error. In Palace del Te at Mantua, Giulio Romano in painting those charming vaults also decorated the hall of the giants. The vaults and walls form but a single surface with rounded angles and no separation. Colossal figures -- giants -- cover walls and vaults, the upper parts of the bodies on the vaults, the lower on the walls. The doors are also cut in the same painting. It is frightful and can only be regarded as the debauch of a great artist. All that can be said of the decoration of the vaults, is that the eye always follows the vault through the entire decoration.

In the modern epoch, Painting has been more dominant in the decoration of vaults, and little by little compartments have given place to painted or carved panels, rather composed for painting than the painting for the compartments. Such is the spirit of the paintings of the vaults of Versailles well known to you, whether in the great salons or the vault of the chapel. Unfortunately in France -- except at Fontainebleau -- are no longer frescos, and oil paintings darken. Again unfortunately, those magnificent vaults of Versailles are not constructed in masonry, but are formed by a series of curved wooden ribs, on which are nailed laths to receive the plaster-

ing. This is a curved ceiling by construction. All ~~accid~~ accidents common to wood occur and compromise the decoration of these vaults, and consequently that of the paintings decorating them.

The beautiful engravings after Lebrun give an idea of these compositions, and I give only the very reduced development of the vault of the gallery of the mirrors (Fig. 462), adding for comparison the most beautiful example of this kind of pompous decoration, the celebrated vault by Pietro de Cortona on Palace Barberini, from a very beautiful drawing of M. Brune. (Fig. 463).

## CHAPTER X. THE DIFFERENT SPECIES OF VAULTS.

SUMMARY. -- Geometry of vaults. -- Their generation. -- Tunnel vault. -- Transverse arches. -- Cloister vault. --Plan square, rectangular or polygonal. -- Spherical vault. -- Lantern. -- Cross vault. -- Piers. -- Lighting. -- Halls of Baths. -- Penetrations. -- Cross vaults and raised penetrations. -- Cross conical vault. -- Torus or semi-torus vault. -- Spherical vault on pendentives. -- Interruptions, drums an domes. -- Vaults on ribs (mediaeval).--Pointed cross vaults.

Everything just stated applies to vaults in general. It remains to see the reasons causing the adoption of one vault rather than another, in each particular case. It is nesessary to rapidly review the various species of vaults, not from the point of view of stereotomy, but in their relations to the general composition.

In case of vaults, you can never neglect stereotomy, for you can neither compose nor design vaults, unless you commence by perfectly understanding their geometrical generation. Elementary vaults have a very determinate generation; thus in Roman antiquity, vaults are distinctly cylindrical or spherical.Later the generation of surfaces is no longer so si ple; there are raised cross vaults called bishop's cap, whose surfaces are quite uncertain at first sight; similarly for trumpets or certain penetrations. Only general advice can be given in this respect, first to advise the very serious study of stereotomy, then to observe as many vaults as possible, first proposing these questions; What is that surface? How is it generated? Can it be developed? And in the contrary case, what may be the rational procedure for its study?

Note carefully, that it is particularly in the study of vaults, that the architect needs all he has learned in elementary and descriptive geometry, and this for only drawing them, without speaking of the methods to be employed for the verification of their stability. There is a grand art in vaults, but this art is denied to one not possessing the necessary science.

The simplest vault is the tunnel vault, purely cylindrical, whether its section be semicircular, elliptical or oval. It requires walls of uniform resistance, its character should

correspond to that function, and generally its decoration emphasizes by its unity the unity of composition and of action of the vault.

In general the tunnel vault is long, its character being to accent a direction, the hall being vaulted in a single sense, and there should be no hesitation in that respect. The tunnel vault on a square or nearly square plan is then not satisfactory, for one asks why the hall is vaulted in one direction rather than in the other. Yet if the tympanums are pierced for lighting, the arrangement is justified; or again if the tunnel vault is connected with other vaulted parts, like the lateral chapels of a church, whose side aisles have cross vaults. The tunnel vault then almost plays the part of a transverse arch.

If the tunnel vault is uniform in construction, its decoration materially consists either of coffers, of compartments with projecting enclosures, or finally of paintings. Only by a development can you study these arrangements.

It will also be frequently divided by transverse arches, either for appearance, or because in an upper story it is necessary to support walls or partitions. The transverse arch is then structural or simply ornamental. This function will be a primary condition of its design, and if it is loaded in a particular way, it is first necessary to satisfy that requirement, the effect of which reacts on the plan by requiring buttresses or other means of resistance under these arches.

If the transverse arches are merely decorative, before determining their projection from the intrados of the vault, the architect must first decide if he prefers to emphasize the length of the nave, or on the contrary to accent its division in bays; in the first case the transverse arches will project little; in the second they will be more pronounced. And since the projection of the arches depends on projections arranged in the plan, in the study of the plan must be foreseen this seeking for appearance.

The tunnel vault risks being dark, and such are frequently the vaults of the first Romanesque epoch. But in churches, at least in France and in northern countries, one is accustomed to this darkness of vaults producing a mystical expression. Elsewhere this defect would be more strongly felt. Hence

great tunnel vaults require means of lighting by penetrations of windows of a special kind, often taking a particular form like oval windows. I cannot do better than cite the waiting hall of the Palace of justice at Paris (Fig. 73). The tympanums at each end are opened in great semicircular windows, and in each bay is an oval window; these windows combined uniformly light the vault, permitting its arrangement to be seen well. One of the most beautiful examples of the tunnel vault with penetrating windows is that of the vestibule of S. Peter at Rome.

Most frequently the penetrations are rectangular windows at bottom, arched at top. Such are the numerous vaults of modern churches. This kind of penetration is analogous to the cross vaults to be mentioned.

Finally are rarely rectangular penetrations, which always have a certain dry appearance opposed to the flexible form of the vault.

As for the decoration of tunnel vaults, it is infinite, from the monumental arrangement of great coffers emphasizing the solemn character of the edifice, as at the Arch of the Star, to the sparkling richness of the gallery of Apollo, the golden gallery of the Bank, the gallery of mirrors at Versail es -- and the sublimities of the Sistine Chapel!

The cloister vault is nothing more than the tunnel vault in two directions instead of a single one, being the intersection of two cylinders with generatrices respectively parallel to the four walls of a hall, from which they spring.

The perfect cloister vault is built on a square plan. But frequently an exact square is not possible in a fixed composition and the hall is rectangular. Then the vault consists of two cylinders of different sections, as one will be semicircular and the other semielliptical. But if there are no difficulties in construction, the appearance is not pleasing if they are too different; one is shocked by the contrast between the four parts of a vault, two being semicircular and two quite flattened. The rectangle forming the base of a cloister vault cannot vary much from a square.

It is entirely otherwise for the vault composed with cloister vaults at the extremities of a tunnel vault, like the vault of the gallery of Apollo, where the section is

the same throughout, and the two half cloister vaults have their crowns connected in a manner by a ridge line. This is badly suited to a plan too nearly square, but is particularly adapted to long galleries by its freedom.

The polygonal plan is also naturally covered by a cloister vault.

Like the tunnel vault, the cloister vault risks being dark. What was said of the tunnel vault also applie here, the cloister vault being suited to all combinations of lighting by penetrations adapted to the tunnel vault.

As for decoration, the cloister vault is particularly the ornamental vault. Very simple, it is already decorative by the flexibility of its lines; examples may be seen in the ground story of the Louvre. Richly decorated, it lends itself to the most beautiful combinations, some examples of which may be cited; in Italy, the admirable vaults of Palace Pitti (Fig. 464) and of the Borgia apartments in the Vatican, with so many others; Here the gallery of Apollo, the golden gallery of the Bank (rather a tunnel than a cloister vault), and particularly the magnificent halls of the second story of the Palace of Versailles, called salons of Peace and of War; finally in more modern style, the square salon and the ahll with seven fireplaces at the Louvre. Only take care that the decoration gives value to the vault by accenting its curvature and height. Decoration that does not clearly emphasize a vault kills it; thus at Florence the cloister vault of the ce tral dome of the Cathedral, which is quite pointed, is absolutely killed by Vasari's paintings; in observing it, one doe not know whether it is a vault or a ceiling, because the structural lines of the vault -- its concave groins --are mar ed by a painting without divisions, which under pretext of unity is nothing mobe than disorder.

But judicious decoration is permitted by the plan. If the hall to be decorated only has flat walls with simple doorways for access, the vault rests on the walls and the decoration remains very free. But if the walls are much opened by arcades or colonnades, these divisions may partly determine the decoration, which will be greatly restricted unless the hall presents angles of a certain value. The plan is always the key to all foresight.

From the vault of a polygonal to that of a circular hall is a very natural transition; in geometry the circle is regarded as a polygon with an infinite number of sides. Yet the difference between these two vaults is profound. While the cloister and tunnel vaults are regular and developable surfaces, the spherical vault, or in general any vault on a circular plan, whatever its section, is a surface of revolution and is not developable, each portion being curved in both plan and elevation. Cylindrical vaults have straight generatrices resting on curved directrices; domical vaults have meridians and parallels, the meridian being circular, elliptical, parabolic, etc., and the parallels are circular.

From this results a property peculiar to the dome, that of already being a complete vault after each horizontal ring of voussoirs is closed, so that it may be stopped at any height desired by the architect without the need of closing it by a final keystone, like cylindrical vaults.

Assume that you are constructing a spherical stereometric vault (Fig. 465). Ten or twelve courses of voussoirs have been set, the last stone of the twelfth being laid to complete this course. Stop there if you wish, even if it be only a third or half of your vault, for you can. How could a stone of that course be overthrown? Not by a force S acting in the direction of the meridian, for this stone is wider at a than at b; not in the direction N normal to the sphere, for c is greater than b. Hence in a domical vault may be left an opening at top of any dimensions preferred. We shall return to this construction.

The domical vault is then frequently lighted from the top by a circular lantern, and also sometimes by penetrations.

Permit some advice regarding glazed lanterns, taking as a starting point the Pantheon of Rome, a circular hall covered by a spherical vault with an opening at the top, through which rain and birds enter.

With us this would scarcely be permitted, and the opening would certainly become a glazed lantern. What happens then? While it rains in the interior of the Pantheon of Rome -- when it rains --in that other Pantheon with glazed lantern it drips in the finest weather. Whether there be a great gathering of persons in the monument or water vapor rising toward

the lantern -- which is inevitable -- the water vapor is condensed on the cold glass and falls in rain, which is nothing else than condensed vapor.

Then it is necessary to separate the lantern from the hall by a warmed space, which cannot be the external air, and hence the necessity for interposing attics between our vaults and the atmosphere.

Do not lightly accept the criticism sometimes made on great domes, S. Peter, Val-de-Grace, Pantheon, etc., whose external outline does not reproduce the internal section. I believe that this difference most frequently results from a desire of the architect for effect and outline. But whether or not intended, there is the other reason of equality of temperature necessary to prevent chilling and condensation. Under another form, this is a reproduction of the arrangement of churches with vaults and attics over the vaults.

Nothing particular is to be said on the decoration of circular vaults. Their regularity lends itself to ornamentation by coffers, by compartments, made in the direction so that the meridians are strongly accented. A spherical vault with only annular horizontal lines or parallels appears flat, whatever its section. Further, even the jointing of the vault, when properly treated, is already a decoration, and many circular vaults have great ornamental sobriety.

With the spherical and tunnel vaults may be classed the annular vault. It does not differ in theory from the tunnel vault, and calls for no particular remark.

The vaults mentioned, excepting mediaeval vaults to be treated later, are vaults with uniform thrust. Here again I must insist on the classification of vaults in two great families, those with uniform, and those with concentrated thrusts. This is of capital importance in the study of plans, for the architect cannot arrange his plan before deciding on the kinds of vaults to be employed; only thus can he attain that perfection of design, avoiding dimensions of points of support, either useless or inefficient.

Assume a hall or rather a gallery to be covered by a tunnel vault and intersected at right angles by a similar gallery and vault with the same width, spring lines and section. The intersection of the two vaults produces the cross vault, well

characterized by its groins, convex if not projecting, in a solid angle increasing from 90° at the spring to 180° at the crown.

The cross vault here assumed is the perfect one on a square plan (Fig. 466).

It may be on a rectangular plan, one of the galleries being wider than the other, but then the sections differ. They may have the same heights with different widths, so that if the narrower be semicircular, the wider will be elliptical (Fig. 467) -- not an oval with several centres -- for the curves of the groins must remain in vertical planes; this groin curve can only be an ellipse, consequently belongs to an elliptical cylinder, and this condition determines the section of one vault after the first is fixed. Draw it and you may verify this statement.

Finally, if the dimensions of the two galleries are quite different, it will frequently be necessary to renounce the cross vault, which would require one of the vaults to be raised too much, and would produce too great differences between the courses. We then have penetrations.

Such are the original elements of the cross vault. It has many other applications, and indeed you find it but rarely at the intersection of two galleries -- in the transept of a church for example -- while you will daily find a series in a portico.

But if I present it first, this is not without motive, which is to show you, that it results from the intersection of two tunnel vaults at right angles, and also that this vault calls for points of support in a diagonal arrangement (Fig. 468). They will be long or short, accompanied or not by cross arches A, but it is only important that the groin of the vault be continued by an angle of the pier. This will only be in the top of an entablature, if you have a column under the spring, but this impost is necessary for the effect, and nothing is more irrational and disagreeable than cross vaults that commence or spring from nothing, as sometimes occurs ( B, Fig, 468).

Thus while a cloister vault requires concave angles in its piers and beneath its intersections, the cross vault requires convex angles. Both for the same reason, that the concave or

convex effect of the vault may continue in the vertical piers

Assume the plan of a gallery with a series of cross vaults (Fig. 469). The projecting piers A correspond to external buttresses; between the two is a simple wall, that receives no thrust and therefore may remain thin. You see mentally that the groin of the vault becomes the angle of the pier, for the form continues with or without an impost.

Do you desire cross arches? They project beneath the vaults and require projections D from the piers, but you must take care, that your cross vaults always have a proper impost, and not make a plan like E (Fig. 470), where the groin ends on nothing.

Do you desire columns instead of simple projections? This is easy, for on your columns (B( the entablature forms the projection, and your plan readily becomes the pier B instead of the pier A, only the decoration being changed.

The imposts of cross vaults may have very different motives Let C (Fig. 471) be a point of support of a portico; you see there two groins, cross arches d d', the imposts r r', one two or three times wider tham the other, but your vault is supported as it should be, the entire vault and piers being in accord.

These considerations are very important and they will be evident, if you mentally conceive your plans for the part above them; I repeat that in the study of a plan, the upper parts must always be present in the mind.

Aside from our initial hypothesis of two galleries mutually intersecting, why are cross vaults built? To light the vaults and the halls, or to concentrate the thrusts? A cross vault must always be justified by one of these motives, often by both.

Take a church with transept, where occurs the meeting of two aisles, the cross vault resulting from the reciprocal penetration of two tunnel vaults. But each aisle is itself covered by cross vaults. Why? There may be several reasons.

If the church comprises a single nave without side aisles, like the Cathedral of Albi, whose plan is shown, a tunnel vault with its continuous thrusts and resistances would present no difficulties in construction. This church is covered by cross vaults to permit lighting in the height of the vaults.

But further, if as shown in the plan of S. Front or that of Noyon, under one form or another, enlargement of the nave by side aisles or galleries, the cross vault responds to two needs; lighting and transfer of the resistances to points where the piers are not encumbrances. This is always, as you see, the art of vaulting placed in the service of the art of planning.

Nothing is then more illogical than the arrangements too common in your projects; cross vaults with tympanum without windows, or when the combinations of thicknesses in your plans do not justify the cross vault. We see in your projects blind cross vaults, projected on the plan of an aisle enclosed by a wall of uniform thickness everywhere. Doubly defective.

In regard to cross vaults, their most monumental expression should be mentioned, the halls of the Roman Baths or of the Basilica of Constantine. Examine the plan (Fig. 472) with the great abutments of the resultant of the cross vaults, themselves connected by great tunnel vaults, and then the eight columns rising from the ground and bearing the imposts of the cross vaults, the centre being again raised above the entablatures forming the imposts; also in the tympanum of the cross vaults the great openings, that light the hall above the roofs of the secondary tunnel vaults. All this has colossal dimensions with the simplest and most judicious means of execution. It is architecture surprised in perfect composition. I regret my inability to cite examples in this vicinity but say this, consider and study the halls of the Baths, for they are to our vaulted architecture as the Greek orders are to our colonnades, the model for reference. This subject will be recalled in treating the Baths in general.

As for the decoration of cross vaults, it will vary according to dimensions. The monumental vaults of the Romans were most frequently decorated by coffers resulting from the construction itself. Yet the coffer scarcely combined with the groin, that must remain intact. Only by development can their arrangement be studied.

In modern vaults there are generally compartments enclosed by the groin lines which ornament the vaults. Finally, pointed vaults are here an important element of the decoration.

and it suffices to cite the cross vault of Villa Madama, a masterpiece of taste and decoration, shown previously (Fig. 455).

Assume a vault of large diameter intersected by one considerably smaller, you do not wish to make the larger sensibly elliptical, and I assume both to be semicircular. The small vault then penetrates the larger, but no longer forms a cross vault.

The line of intersection is then one of double curvature. (Fig. 473). But considerations already stated for cross vaults are applicable here. The thrusts are concentrated on the same piers or buttresses, the tympanum wall is likewise a mere enclosure without thrust, the vault with penetration permits lighting through the tympanum, the only difference being that this lighting does not rise to the crown of the great vault, which retains the character of a tunnel vault.

The penetrating vault lends itself to combinations with the cloister vault.

Here is a hall (Fig. 474) covered by a cloister vault, but in each quarter is a penetration permitting the lighting of the vaults and concentrating the thrusts on the solid angles.

An octagonal hall (Fig. 475) is similarly covered by a cloister vault, and in each of the eight cylinders being a penetration, the same results occur.

Finally, it may be said, that penetrations in a spherical vault produce a plane curve. This introduces some words on arched openings in circular halls, which are often projected. If the curvature of the wall be pronounced, the appearance is very bad and the stability is very doubtful (Fig. 476). The key of the arch is entirely outside the straight line joining the imposts, and the arch assumes the extremely bad appearance of being overthrown. Examples may be seen in the choirs of certain churches, S. Thomas Aquinas, S. Roch, and in the hall for the sittings of the Institute.

Externally this effect is that of an overhang, perhaps less disagreeable, but not less dangerous, for this entire arch tends to fall outward.

It is entirely different with the arch of penetration in a spherical vault, where the intersection is a semicircle and a plane, with entirely satisfactory appearance and stability.

We shall recall the last combination when studying the vaul on pendentives.

Cross vaults and penetrations so far mentioned are purely cylindrical. But frequently greater height is sought for the penetrations, either in both senses or only one. Thus a smaller vault penetrates a larger, like the vault of a church. If Both cylinders are semicircular, this is a penetration, if the larger be made elliptical so that the crowns are on a level, it is an oblong cross vault. Yet you can still retain the semicircular section for each vault and have complete cross vaults, if the crown of the small vault is raised from a to b by the difference of the radii. Then the large vault remains cylindrical, but not the smaller (Fig. 477).

It can neither be conical nor conoidal, for its directrix must be tangent at the crown of the large vault, and a generatrix of a cone or conoid would be tangent lower; then appears an inclined penetration (Fig. 478) entering further into the large vault than cylindrical penetration, and which is a conoid in the figure, but not the raised cross vault sought, unless the large vault be pointed, having as directrix two axes, such that the top generatrix of the cone or conoid may be tangent at the crown (Fig. 479), and the groins will not be plane curves.

In any case, the small vault must be a surface with its middle section tangent at the crown of the large cylinder, and that can be cut in a semicircle by the small cylinder. If the large vault be cylindrical, this section is necessarily curved, being horizontal at the crown and inclined at the springing.

These surfaces of penetration with double curvature are som times very difficult to determine geometrically, and they are often realized by trial rather than by method. Yet for their study it is necessary to know fully the generatrix of these surfaces, to see which are possible and select the most practical. In the present case, I describe this surface as follows.

To obtain a curve C c (Fig. 480) tangent at the crown C, pass through the crown c, permitting a RIGHT HALF semicircular section for each cylinder, and consequently elliptical ON THE diagonal~~ly~~ E. I first find that this curve of intersection will be a half slipped, then the surface of penetration will [illegible] ellipsoid of revolution, and since in all curves [illegible] tion, all meridian sections are identical, this [illegible] will have in plan the same section p 0 c.

The intersecting lines will then be meridians of that ellipsoid, intersecting [illegible] the joint lines of the cylin[illegible] The surface being thus determined, at least you know [illegible] is to be adopted, while if you do not take this [illegible] [illegible] of vaults [illegible] you will find [illegible] study hook.

These raised vaults also occur on a second plan [illegible] cross vault is formed a [illegible] cap. That gives [illegible] [illegible] [illegible] not conspicuous, and also diminishes the loss of [illegible] It is then a very judicious procedure, the stereotomy and construction of the vault more difficult; the geometrical preparation of the vault [illegible] shown.

The horizontal projections of the groin [illegible] be for the cylindrical cross vaults. The [illegible] vault may be of various kinds; [illegible] section and vertical [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] intersection, [illegible] [illegible] [illegible] [illegible]

Thus each of the four parts of the vault [illegible] [illegible] vertical plane, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] and [illegible] [illegible]

ellipse, hence the surface of penetration will be part of an ellipsoid of revolution, and since in all surfaces of revolution, all meridian sections are identical, this ellipsoid will have in plan the same section p C c.

The joint lines will then be meridians of that ellipsoid, intersecting at the groin the joint lines of the cylinder.

The surface being thus determined, at least you know what is to be studied, while if you do not know the geometrical generation of vaults used, you will find yourselves unable to study them.

These raised vaults also occur on a square plan, when this cross vault is termed a bishop's cap. That gives an appearance of height often very desirable for the vault, and also when the vault is below a story or terrace, it permits thinner compartments and thus diminishes the load on the vault. It is then a very judicious procedure, but makes the study and construction of the vault more difficult; in all cases, the geometrical generation of the vault used must be well known.

The horizontal projections of the groins will be the same as for the cylindrical cross vault. The surfaces of the vault may be of various kinds; one may employ cones of revolution with vertexes S' outside of the vault and at the level of the springing (Fig. 481). The groins are then elliptical arcs intersecting at the crown at an angle more or less large really the diagonal arc is here pointed elliptical. But you note that the upper generatrix of the cone being tangent at the crown of the diagonal intersections, these must make a pointed angle or arch, without which would occur the former case of the conical projection.

Thus each of the four parts of the vault may consist of a conoid with directing vertical plane, whose sections are respectively a semicircle at the lower part and a half ellipse at the centre. The entire horizontal projection, groins and joint lines are then identical with the projection of the cylindrical cross vault; only instead of the joint lines being horizontal, they are more and more inclined, the surface being warped (not developable). This system then presents great difficulties, and in making the complete sketch, you see that it is impossible to have everywhere plane joints between vous-

To Here

soirs. The jointing is then very difficult and is never perfect.

These combinations have this in common, that the line of the crowns is a straight ascending line, which gives a dry appearance to the vault. It is generally preferred that this line be curved, as we have seen in penetrations.

Generally the curves of the groins are first fixed, then the ridge curve, when the rest of the surface is found by trial. But it is always best to employ well defined surfaces by having recourse to general combinations.

Easiest conceived is the intersection of two ellipsoids of revolution (Fig. 482); but the ellipses of the base being fixed, the height of the crown results necessarily, for this height above the plane of the base will be precisely equal to the half-minor axis of the ellipse of the base.

Thus the vaults cannot be raised much. Their section will be identical with the curve of the ellipse on the plan, which can never much exceed the inscribed square. To obtain a higher vault, a first means is to employ portions of ellipsoids, (Fig. 483). Assume that the horizontal line A B C belongs to a half ellipse, whose major axis is C O, and the curve will be more open in plan and section, only as shown for cones, the diagonal arch will be pointed ellipsoidal. I add that the variable solid angle along the groin is necessarily quite obtuse.

Finally, a sort of torus may be formed (Fig. 484), though not properly called a torus, by passing through the crowns c, c an arc of the circumference of the circle c C c with a radius such that its centre falls lower than the plane of the springings. If from various points of the circle of the tympanum A c, notably from points of intersection of the jointing lines, we pass circles traced with this point P as pole, a su face of revolution is obtained, whose oblique section A c wil be a semicircle, and its right section will be a curve only to be determined by points. If we construct another similar surface perpendicular to the first and entirely reciprocal, these two surfaces will intersect in the line A G A, the projection of two elliptical half groins in the general case. In a particular case it might be fixed at first that this groin would be a semicircle, and then the height of the crown

is fixed, being in proportion to the heights of the crowns of the head circles in the ratio of the diagonal to the side of the square, and the pole of the parallel circles is the centre itself of the horizontal plane of the springings. But then each of these surfaces becomes a part of the same sphere, and there is no longer an intersection. The ellipse A C A is nothing more than the projection of a diagonal great circle of the sphere, and we actually find the vault on pendentives mentioned recently, and which is thus the limit of this kind of intersection.

From the point of view of execution, the ellipsoidal vault has an incontestable advantage; the generating lines are also the lines of jointing and are here meridian curves, determining normal plane surfaces, always very desirable in jointed vaults, while in the latter combination of semi-torus surfaces the joint lines being parallel and not meridians, the normal surfaces will be conical, more difficult in execution.

A rarely employed kind of vaults has some analogy to the preceding. These are vaults annular in elevation, torus or semi-torus. Assume a rectangular area in plan like that covered by a rectangular cross vault. The wide faces A A', B B' will be semicircular, as well as the smaller ones A B, A' B' (Fig. 485). The surface of double curvature indicated by A B C' A' B' in plan and B c C S B' S' in elevation may be a torus, but not as erroneously assumed to be by admitting a parallel displacement of the small circle AcB, for by this would be obtained a vault raised too much (Fig. 486), which would certainly not produce the effect expected.

The problem is the following; assuming the section A c B, oblique with reference to the torus, to be a circle, what would be the right section of this torus? It is easily seen to be an ellipse, whose major axis equals the diameter A B, and its minor axis equals the distance from the circle of the centres to the meridian circle (Fig. 487). Thus is obtained a surface of constant curvature, easily jointed, while the preceding would have a constantly variable right section. The appearance of the vault so traced is much preferable, as easily seen by the transverse sections.

It is further clear, that the torus vault always having its springings tangent to a vertical, should be received and

stopped by the projection of an archivolt of the cross arch; its architectural representation will then be nearly that of Fig. 488.

But a nearly similar vault, although of a very different generation, may again satisfy the problem if proposed thus:— what should be the geometrical surface such that four vertical planes parallel in pairs intersect it in semicircles? It is evidently a sphere. Then is obtained a vault with a clearly defined surface (Fig. 489), and it will be jointed either in horizontal voussoirs circular in plan, or by sections by parallel vertical planes giving lines of voussoirs circular in elevation.

This combination falls in the series of pendentive vaults to be examined immediately.

Note that these vaults must not be confounded with those known to you in the waiting hall of the assize court of Palace of Justice, composed of parts of vaults of double curvature and of flat section not enclosing the cross arches but independent. These are light vaults supported by masonry walls recessed in great arches.

The vault on pendentives is one of the most beautiful inventions in architecture, for the problem was singular; given a square hall to be covered by a spherical vault. Antique architecture did not propose that question, at least so far as I know, excepting only in the monuments of Persia.

Toward the end of the Roman empire the pendentive vault appears to have been introduced in Greco-Roman architecture. A fertile invention, that gave us S. Sophia of Constantinople, S. Mark of Venice, S. Front of Perigueux and S. Peter of Rome!

You know that all this is admirable, but perhaps you do not know the how and why of these admirable things. Let us return to geometry.

The pure pendentive vault (Fig. 490) is a spherical vault, whose diameter is the diagonal of the square covered. Very simple, as you see, and it is sufficient to invent it. Assume a circumference to be circumscribed about a square, whose diameter is the diagonal of the square, and that this circumference is made the base of a spherical vault; the four walls of the hall are vertical planes and intersect the sphere in circles, the hemisphere in semicircles. This is the whole of

the pendentive vault in plan and section. Diagonally, its section will be a great circle of the sphere.

Note first, that the pendentive vault has numerous analogies to the cross vault; like that it has tympanums suited fo the lighting of halls; it likewise transmits the thrusts to the corners, and consequently the tympanum can be opened; the pendentive vault, like the cross vault, can be made the intersection of two aisles with tunnel vaults. It has greater height, thus approximating the bishop's cap vault, and like that, it cannot omit cross arches, when the tympanums are open, to define the transition from the tunnel to the ra raised vault.

The pendentive vault on a square plan has the inconvenience of lacking a springing for the spherical vault (See diagonal section, Fig. 491). Thus this springing is generally ensured by a narrow oblique splay (Fig. 492). Then the sphere has for diameter the diagonal between these splays, and these splays should actually be circular.

Thus when their width is considerable, as in domes of churches, if the splay be straight in plan while merely playing the part of a pier, it becomes circular above the springing of the vault; the projection of the impost masks this transition (Fig. 493). The plan and sections of the hall are expressed in Fig. 494.

But I have stated that the spherical vault might be stopped at any one of its annular courses. It is naturally the same for the pendentive vault. This may be at the circle tangent to the tympanums, the first complete one.

Hence at S. Front of Perigueux (Fig. 495) is a very singular procedure. To ensure the vault the greatest thickness required at the springings, the pendentive vault is interrupted at the circle tangent to the tympanums. Then a purely spherical vault rests on this, double on the former, single in the entire upper part.

This possibility of interruption then permits horizontal circular openings and lighting from above, as at the Madeleine. But they went farther, for on that interruption taken as a circular base were built cylindrical walls, pierced by windows, themselves covered by spherical vaults. This is the system of the great domes of churches, S. Peter of Rome, S.

Paul of London, Val-de-Grace, the Invalides and the Pantheon. Bold construction that represents science.

To take this into account, examine the purely geometrical scheme of one of these monuments cut diagonally (Fig. 496) and its very simple architectural expression (Fig. 497). The pendentive vault supports the entire weight of the drum and of the spherical vault, transferring the stress to the piers, thus exposed to considerable thrusts. Only by combinations in the plan can sufficient resistances be ensured; the plans of monuments just cited are very remarkable and instructive; perhaps before all others that of the Invalides, where the composition peculiar to the pendentive is translated into the architecture from the base of the edifice to even the summit of the dome.

You see what resources the pendentive vault has created, and that architecture has known how to profit by it. I have cited admirable examples; study them, for architecture has no nobler subjects to propose.

I pass to special vaults, such as rampant tunnel vaults, S. Gilles' screw, annular vaults, annular cross vaults, etc. Stereotomy defines and explains them, and from the point of view of composition, those with uniform or concentrated thrust are easily recognized. This explanation is quite dry and geometrical, but it is necessary, for the geometry of vaults is the first thing to be known by one wishing to vault edifices; then comes stereotomy, or the art of jointing, for which you are referred to special treatises; I only give what is necessary to composition, while directing your entire attention to this study; you will only acquire it by making the drawings comprised in it.

I come to speak of mediaeval vaults, on which a word has already been spoken. You already know that these vaults have compartments supported by a skeleton essentially composed of ribs. It might be said, -- though an exaggeration -- that the middle ages did not construct vaults, but only ribs and compartments.

These ribs generally rest on compound piers, and sometimes on simple corbels.

The combination of these vaults are much varied, yet they are rarely applied to tunnel or cloister vaults; the trans-

formation of the vault into ribs naturally results from the establishment of resistances at certain points only, at the springing of the ribs; this system is then more suited to the theory of concentrated thrusts than to that of uniform thrust Hence one might say in general, that after the tunnel vaults of Romanesque architecture, mediaeval vaults always have concentrated thrusts.

If we restrict the expression "mediaeval vaults" to the vaults of the pointed period and the Romanesque architecture, up to that time we see two sorts of vaults employed in churches; the semicircular vault in a certain number of Romanesque churches, the pendentive vault in Byzantine churches, and in the South and Southwest of France.

The pendentive vaults by the localizing of thrusts, permit plans of churches much more varied and bolder than the tunnel vault; it also allows much better lighting of the centre aisle Then abandoning the tunnel vault, the architects devoted themselves to successive studies of the pendentive vault; they first reinforced the pendentive by diagonal arches, actual permanent centres and directrices in stone, and then by successive transitions -- for such is always the course of artistic evolution -- they reached the conception called hexapartite vault. This appears to me proved perfectly by the scientific researches of M. Corroyer (Architecture Romane; Architecture Gothique).

This origin explains the fact, that the mediaeval vaults are always raised; I do not believe that purely cylindrical ones exist, and the most ancient, like those of Angers (Figs. 498, 499, 500) or of Laval, are most curved, their sections through the crown being precisely that of a spherical vault on pendentives. These ancient vaults are further on square plans, like the pendentive vault, and it was later that vaults were constructed on rectangular plans.Only you will note here, that the square plan of the vault is obtained by the combination of two bays, the arch through the crown perpendicular to the side walls being really a cross arch. This again demonstrates, that the tradition of the square plan required for the pendentive vault is continued in spite of the rectangular form of the bays. This arrangement is further common in the middle ages, and is found notably at Notre Dame

of Paris.

I mention these questions of origin only to show you that the mediaeval vault does not really belong to any species of vault previously examined, and I reserve to the study of church architecture the esthetic questions comprised in this subject; this is not a cross vault, or a spherical vault on pendentives, but a combination of ribs of very precise curvature with compartments of much less determinate generation, sometimes very awkward. Once these ribs are drawn and properly erected, the compartments were a slight affair of inspiration on the spot, the ribs alone serving for support, guides and patterns.

The mediaeval vault has for prototype the hexpartite vault, a combination of six ribs playing the same part in pairs (Fig. 501). If the plan be drawn at the springing, one first notes the transverse ribs connecting opposite piers, and then the side ribs attached to the side walls. The transverse ribs are thrown from one wall to the other, forming supports for the compartments, the side ribs being applied against the external wall, thus forming a curved projection to also receive the compartments. These ribs are all semicircular in Romanesque architecture and are pointed in Gothic architecture. Finally, there are diagonal ribs, also termed groin ribs, that form the groins. These are generally elliptical and are traced so that their crown dominates those of the transverse ribs, while frequently the crowns of the side ribs are higher than the central crown, so as to favor the penetration of light as much as possible.

These different ribs are of cut stone, jointed carefully; the compartments are of rubble and sometimes of bricks. This is the very simple vault of the middle ages, but it is often more complicated.

First the transverse ribs are frequently accompanied by two side ribs and the crowns are frequently marked by ribs; transverse ribs D, side ribs F, F, groin or diagonal ribs H, crown ribsC. C (Fig. 502).

Particularly in the larger vaults are ribs multiplied and with reason. The entire stability of these vaults is in the ribs; the compartments have no stability of themselves. The architect should then avoid too large compartments, just as

he should avoid a multiplicity of encumbering ribs. But these ribs are always in vertical planes and are plane curves.

These combinations of ribs, because perfectly appropriate to projecting intersections like groin vaults, are less suited for concave intersections. Thus the middle ages scarcely employed the cloister vault, and even for polygonal halls(Fig 503) the vaults still rest on the ribs and are combined with the tympanum, being still cross vaults.

In general, as I have shown, to a particular composition of the vault corresponds an analogous composition of the pier. Yet these arches also frequently spring from corbels, and notably when the groin rib springs from a concave angle of the pier.

I cannot enter into all the detail of these vaults, whose combinations are infinitely varied, but can only refer to special works, where you will see that architecture has again followed there the usual procedure of the human mind. After exterminating, it has reached the logical and necessary expression of its work, and then has sought boldness and variety, then producing elegant and ingenious combinations th charm us; it has also accomplished feats by seeking difficulties for the pleasure of solving them. Attaining this, an art has fulfilled its evolution and has no other alternative before it than decadence or renovation. The Renaissance was not merely a fact, but an inevitable necessity.

The Renaissance did not at once abandon the vaults of the middle ages, but impressed its stamp on them, gave them the imprint of its taste and elegance, and also in the order of ideas it built masterpieces, even if only the vaults of S. Eustache, or those of the chapel of the Chateau of Ecouen. (Fig. 504). There were even very ingenious and artistic combinations of ribs and of ceilings of stone slabs. One of the most remarkable examples is the vault of the Church of Tillieres (Fig. 505).

Then the system of vaults completely disappeared and only the stereometric vault was constructed; everything contributed to that, the inspiration of antiquity —— in its form more than its construction —— especially the violent rupture of the modern spirit with the mediaeval spirit, an intellectual break, that could not occur without an artistic rupture also,

to such a degree that even recently the art of the middle ages, so profound, skilful and finally so refined, was regarded as the barbaric expression of what Quatremere de Quincy called ignorant building.

I do not have to state my personal preferences, but I think that nothing is to be rejected, and that everything transmitted to us by our art merits study, on condition of understanding it well and knowing its scope.

I have sought to exhibit the profound differences existing between the different vaults, and at the same time the unity of these studies. The vault is always a contest with danger.

The vault is a magnificent element, a seductive temptation, and the mind always leads to the vault, when it is necessary to express the monumental, grandeur of appearance, nobility of the edifice. But to triumph over the difficulties of the vault and its perils requires art and science. The vault is difficult architecture, only permitted to the strong; it's study being composed of prudence and still more of foresight; from its beginning, from the composition of the plan, you ensure the possibility of your vaults, while remembering that the means will never be too simple.

I shall congratulate myself if these lectures on vaults have shown you in them a motive for very serious and thorough studies; that the vault is not a mere pretext for decorations, caprices and fancies; that the architect who conceives vaults must know what he does, understand the geometrical generation of the surfaces employed, and foresee what resistances must appose their forces.

The vault is a superb element, and you will fashion it after your own ideas, yet you enter as in a contest; be not vanquished!

## CHAPTER XI. STAIRWAYS.

SUMMARY. -- Straight and curved stairs. -- Their element -- Stairs between walls. -- Height and width of steps. -- External flights of steps. -- Landings. -- Lighting of stairways. -- Stairs of stone -- wood -- mixed.

Steps with landings and overhangs. -- Gentle ramps.

Until now, you have examined the wall and its openings, pie columns, orders and porticos, all of which are vertical; roof floors and vaults, all of which are horizontal. Between all these is the vertical conncetion by the stairway.

Little will be said now, reserving till later the study of the stairway as a special composition and as an enclosure, only treating it here as an element.

Is it not useless to explain to you steps, landings, etc.? All that may be in stone, wood or iron; likewise the railings; I prefer rather to indicate the relations of the combination of stairways to the general composition.

Stairways in all antiquity, in the entire middle ages, proceed from the same system of steps like lintels, either resting on rampant tunnel vaults, between two walls, or between a wall and a solid central newell, when the stairway is curved. In Latin or Italian a single word "scala" signifies both ladder and stairway, because the stairway was at first merely a stone stair, even in the richest palaces, as the stairs of Henry II at the Louvre, in Palace Farnese, in Palace Doge of Venice, which does not prevent these stairs from being magnificent.

The principle of construction is the same for the stairway of Blois and that of Chambord, or for those of Caprarola and of Palace Barberini, and finally for the grand stairways in three flights, like that of Caserta, the steps everywhere forming a lintel between two walls or between a wall and a newell.

There were invented -- I cannot state where or when they first occurred -- what are called self-supporting stairs with strings of stone, wood or iron. Such are the so-called French stairways. I should enter too directly into stereotomy, if I sought to describe them. Their common character is, that the steps are fixed at one end in the wall of the enclosure, at the other being supported over space by the strings. These

stairs always have a railing (stone, wood or iron) on the fre side.

Further, straight or curved, with newells or strings, the stairways require the same considerations from the point of view of the composition.

They must be easy, the proportion of width of steps equal to twice their height being frequently adopted. This may be said to be a minimum, for the stairways of our monuments, such as those of the Louvre, of Versailles, etc., being much easie

Here is a Table, that will indicate the proportions of widt and height of steps of some celebrated stairways.

Table A.

| Edifice. | Width of tread. | Height of riser. | Rise per ft. run. |
|---|---|---|---|
| Louvre, stairs of Henry II | 14.0" | 5.5" | 4.6" |
| Louvre, stairs of colonnade | 15.8 | 5.8 | 3.25 |
| Versailles, marble stairway | 15.8 | 5.5 | 4.2 |
| Invalides, grand stairways | 15.0 | 4.7 | 4.2 |
| Palace Royal, stairs of honor | 15.3-15.0 | 5.7-5.5 | 3.25 |
| Conservatory of Arts et Trades, stairway | 16.5 | 5.3 | 3.88 |
| Pal. Luxemburg, stairs of senate | 14.6 | 5.9 | 4.85 |
| Pal. Lux. stairs of president | 14.6 | 5.3 | 4.4 |
| Mint | 13.0 | 5.3 | 5.6 |

These examples suffice to show that in monumental architecture very gentle stairways have been sought. In more ordinary conditions, stairs are more or less steep, the usual proportion being to make the width of the steps twice their height, or 6 ins. rise per foot run of the stairs on the plan sometimes, as in stairs in towers, the inclinations reach almost 45°. This is done when necessary and cannot be otherwise but these stairs are difficult and dangerous.

It is the same for cellar stairs, frequently made much too steep, and yet they are intended for heavily loaded men.

Italian stairways, notably at Rome, are in general more easy than ours, one scarcely perceiving the ascent. Those lea ing to the terrace roofs of S. Peter at Rome allow passage of mules carrying materials for repairs, which ascend and descen without accident. Some examples have been collected in the next Table.

## Table B.

Internal stairs. Italian edifices.

| Edifice. | Width of tread. | Height of riser. | Rise per ft. run. |
|---|---|---|---|
| Rome, Palace Cancellaria | 15.8" | 6.5" | 4.9" |
| Rome, Palace Giraud | 17.4 | 5.95 | 4.1 |
| Rome, Palace Doria Pamfili | 15.6 | 5.7 | 4.4 |
| Rome, Palace Farnese, exit | 23.2 | 5.2 | 2.7 |
| Rome, Palace Farnese, ordinary | 21.2 | 5.2 | 3.0 |
| Rome, Palace Borghese | 16.1 | 5.3 | 4.0 |
| Rome, Palace Barberini, rectang. | 18.2 | 5.2 | 3.45 |
| Rome, Palace Barberini, oval | 18.8 | 4.95 | 2.7 |
| Rome Palace Corsini | 16.9 | 5.2 | 3.7 |
| Rome, Palace Braschi | 14.8 | 5.6 | 4.6 |
| Rome, Palace Vatican | 15.9 | 4.7 | 3.55 |
| Rome, Museum Vatican | 14.6 | 4.5 | 3.7 |
| Venice, Palace Doge, goldenstairs | 12.7 | 6.7 | 6.3 |
| Venice, Palace Doge giants' stairs | 11.8 | 5.7 | 5.8 |

External flights of steps should be, and often are more easy. Steepness would be more dangerous there because the rain wets the steps, and all that makes them slippery, frost, snow or mud. The treads must also be inclined to remove water. Some examples will be useful and are given in the Table.

## Table C.

### External Flights of Steps.

| Edifice. | Width of tread. | Height of riser. | Rise per ft. run. |
|---|---|---|---|
| Versailles, the hundred steps | 15.8" | 5.5" | 4.2" |
| Versailles, horseshoe steps | 15.8 | 5.8 | 4.4 |
| Versailles, central steps, garden | 14.9 | 5.5 | 4.4 |
| Versailles side steps | 14.3 | 5.3 | 4.5 |
| Fontainebleau, court of honor, straight | 16.3 | 4.3 - 5.1 | 3.5 |
| Fontainebleau, " curved steps | 14.2 | 4.15 | 3.5 |
| Fontainebleau, court of fount. | 17.3 | 5.3 | 3.7 |
| Fontainebleau, in park | 14.9 | 5.9 | 4.75 |
| Pal. Justice, court of honor | 16.1 | 5.3 | 3.9 |
| Pal. Justice, Place du Harlay | 15.4 | 5.5 | 4.3 |

Table C. Continued.

| Edifice. | Width of tread. | Height of riser. | Rise per ft. run |
|---|---|---|---|
| Conservatory, Art et Trades, court of honor | 13.8 | 6.3 | 5.5 |
| Tuileries, to terrace Solferino | 14.6 | 4.9 | 4.1 |

I prefer to cite those easily seen at any time. These proportions are also very near those found everywhere, but alway more easy in Italy.

As for stairs with very broad steps, they rather belong wit easy ramps. Thus at Versailles, the horseshoe steps commence as ordinary steps 15.8 × 5.8 ins., then continue with broed steps 47.0 × 3.9 ins., or a rise of 1.56 ins. per ft. run. These steps are composed of stone borders enclosing paved blocks 4 ins. square.

When the stairway is curved, the dimensions of the treads and risers of the steps must be applied at the middle of thei length, which is called the travel line.

In stairs composed of straight flights and curved parts, abrupt transitions from one kind of step to the other must be avoided. Thus after laying off the treads on the travel line at the points o, A, B, C - - - N, O (Fig. 506), if the risers were drawn normal to the string, the dotted lines would run to the points c, 1, 2, 3, - - - 14, 15, which would be bad, for near the string one passes suddenly from one slope to another, making it inconvenient and dangerous. Recourse must be to balancing (full lines) at o, a, b, c, - - - n, o, that permits these differences to be greatly modified.

When a continuous curve permits unequal curvatures, as on an elliptical stairway, it is also well to correct irregularities by balancing. Such is the plan of the oval stairway of Palace Barberini (Figs. 507, 508), whose string is supported by a rampant colonnade.

In all cases of balancing, the proportions of the steps remain unchanged on the travel line.

Landings are of two kinds, those at top and intermediate. In general, one rarely ascends more than 10 to 13 ft. without a landing, which must be sufficiently wide to permit several steps, for the change of steps rests one in the ascent. Too small a landing only breaks the step without resting, and this is disagreeable.

The length of the landings must at least be the length of the steps, since several persons beside each other ascend or descend the stairs, so that the same order should be kept on the landings.

The top landing is arranged to be as nearly as possible at the centre of the arrangement served by it; every stairway must facilitate departure and allow those arriving to circulate at once. The lightin

The lighting of stairways is often very difficult. Nothing is more disagreeable or inconvenient, than a stairway cutting obliquely across the windows of a story, which then cannot be opened In the middle ages and the Renaissance, at the celebrated stairway of the Chateau of Blois (Fig. 509), or that of the Chateau of S. Germains (Fig. 510), the windows of the stairways are at different levels or sometimes are rampant according to the steps. That is only possible in certain cases, and at best is a question of personal taste. But windows thus displaced injure the stability of the edifice, being an interruption to the ties required at the level of each story.

All these inconveniences are avoided when the stairway can be lighted from the top landing, though not always permitted by the general arrangement. As for vertical lighting by a lantern, it is only possible for grand stairways or if only one story is to be served, for otherwise the light does not reach the bottom.

Thus are many difficulties for which are no constant solutions. The foresight of the architect here permits the adoption of the best arrangement possible in each particular case.

Monumental stairways are generally of stone. In certain regions of France, notably Lyonnais and Provence, even very ordinary stairways are only of stone. Naturally, hard stone is necessary, that wears as little as possible. If the stairway has limited dimensions, the steps may be lintels between two walls, or a wall and a string. Otherwise they must be supported by rampant vaults, tunnels, S. Gilles' screw, or half vaults with trumpets (Fig. 511). You will study these special vaults in treatises on stereotomy.

In any case joints should not divide the length of the step except for external flights with widths not permitting monolithic steps. But at least the jointing must be regular.

Many ancient stairways are found with solid steps, the same stone (A b) forming the step and the ceiling beneath (Fig. 512). This arrangement has a serious inconvenience in maintenance, for when a step is worn out -- which always happens in the end -- to replace it is a difficult and costly operation. This danger is avoided by using treads of hard stone, that may easily be changed (Fig. 513), better because the treads generally have nosings, at least for internal stairs. In case of repairs, it is only necessary to change the tread, which does not interfere with the stability of the construction.

Whether the stairs are supported by one or the other method if the arrangement of the stairs includes a central well hole the steps terminate there -- as well as the landings -- again a string of hard stone, which you learn to draw in studying stereotomy. This string in turn supports the railing, either of stone or iron, as well as the hand rail above it. As indicated for balconies, there must be in these railings more stable parts, pedestals forming the structure with connecting parts. At the turns or angles must be especially sought the elements of stability. You find here an example of a stone railing with balusters (Fig. 514); the variety is much greater for metal railings, from simple bars to the richest orname al panels. One of the most interesting models is the magnificent railing of the stairway of Palace Royal (Fig. 515) in po ished iron and bronze, one of the most remarkable works in iron of the 18th century.

Stairways of wood were formerly made with solid steps, but this practice is abandoned, its inconveniences being even more apparent than for stone. The steps of wooden stairs are made of treads about 2 ins. thick and risers of less thicknes (Fig. 516). The under surfaces may be visible, decorated by mouldings, sculptures, etc., cut in the wood or applied, but generally an inclined ceiling is made of plaster on laths, that receives the decoration like an ordinary ceiling. This ornamentation should always be simple and not comprise strong reliefs.

Wooden steps, like those of stone, are supported by wooden strings, which are of two sorts; extending above the steps after the fashion of stone strings, they are termed French,

and directly support the railing of wood or iron (Fig. 517). Or they are English, cut out to receive the step, that extends through (Fig. 518), when the nosing of the step is returned on the string.

The construction of wooden stairs readily lends itself to an arrangement of posts at each angle of the landing or turn in the direction of the steps. It is then analogous to the stone stairs with strings supported by piers or columns, the steps actually resting on a wall at one side and a wooden beam at the other. But these parts are often interrupted and rather become newells serving for the connection of the strings, or of the strings with the landings; such is the stairway of the pavilion called Chartreux at Palace Luxemburg (Fig. 519). The railing is then made in panels and may comprise the greatest variations, either of wood with balusters or perforated carvings, or by the use of metal.

Finally are stairs with iron framework with steps formed of treads of stone, marble or wood (Fig. 520). The strings and risers are of plates connected by angles, and a framework of horses and ties forms a rampant carriage under the steps. The whole is lathed and plastered beneath; the strings are either French or English. The arrangement is usually the same as for wooden stairs.

In all stairs with unsupported strings -- self-supporting-- the dangerous part is always the landing of two kinds, those having the entire width of the stair hall (Fig. 521), generally between stories or sometimes in the middle of a story, and the secondary landings, or those for rest. The former present no difficulties, a landing step being formed by a beam of woo or iron fixed in both walls and forming the last step of the lower flight as well as the start of the upper one. Between the landing step and the walls extends the landing, supported by joists. The rest landings are less easily constructed (Fig. 522). If arranged to form a landing step, nothing prevents the anfle from sagging. Hence a diagonal beam is fixed in the two walls and crossed by another with strongly fixed end, half its length overhanging, but supporting the string if strong enough not to bend. This artifice evidently cannot afford absolute security and requires perfect construction. Thus frequently such landings are seen with steps inclined toward the string, which has a bad and suggestive ef-

fect. But this arrangement of stairways may often be necessar

With stairways it is proper to treat the easy ramps, which are rather more fatiguing to persons on foot, who generally prefer to use the stairway than the ramp, if there be a choice. Yet it is necessary for carriages and horsemen.

Ramps should indeed be easy, for according to the programm they may be designed for the passage of loaded wagons, like those in Paris descending from the quays to the banks, or eve in a park as at Versailles the horseshoe ramp of the great lawns, that serve for wheeling the boxes of orange trees, wagons with materials, etc., or they may serve for light carriag or horsemen. In the first case their inclination should not exceed what is adopted as the maximum for foads, about 6 per cent; still if the ramps are short, since the effort is not prolonged, this slope may be slightly exceeded. It may be a little greater without ever exceeding 8 per cent for carriage or horsemen. This shows that to pass from one terrace level to another requires a great distance. The plan of the ancient ramps of the Chateau of S. Germains (although intended for riders and not for carriages) is typical in that respect (Figs. 523° 524). When ramps are curved, care should be taken to slightly raise the external curve so as to oppose the centrifugal force in a rapid descent. In ramps composed of straight and curved portions, it would be better to make the latter as landings, so as to arrest the rapidity of the carriage at a point where the dsecent is particularly dangerous. At least it is wise to make the inclination much less at the turns and to have recourse to balancing.

In the study of ramps, if not made by lines of steps, it should be done with lines of levels at regular intervals of the height (Fig. 525). Thus the sketch shows you the lay-out of a ramp in a curved plan with inclination reduced at the curve and forming a channel there, so as to prevent the carriage from being thrown against the internal side by the more pronounced inclination of the shorter curvature, or against the external side by the centrifugal force, while it is convex in the straight parts. These sketches can only be preliminary, and there is always opportunity to retouch them by drawings made as large as possible to correct breaks. Easy ramps then afford very beautiful architectural motives, such

as the access to the promenade of the Pincio at Rome(Fig. 526

I shall return to stairways in speaking of the halls contai ing them, and their importance in the copposition. At present I only desire to show the elements composing them, without being able to exhibit all the varieties of their infinite for for scarcely on any other subject can the imagination of architects have a freer career.

## CHAPTER XII. SECONDARY ELEMENTS OF ARCHITECTURE.

SUMMARY. -- Half timber work. -- Half iron work. -- Marble work. -- Effect produced by color, blocks and facings, pavements. -- Joinery. -- Frames and panels. -- Doors, windows, paneling. -- Ceilings of woodwork. -- Locksmith's work. -- Fixed and opening grilles. -- Metallic architecture.

This general exhibition of the elements of architecture would be incomplete, if I did not speak -- very briefly -- of the secondary parts, that do not sensibly influence the composition of an edifice, but are important in its design, like joinery.

In this order of ideas is first found Half timber work, or facades in visible woodwork. I refer you to works on carpentry for the composition of wooden framework sheathed or plastered, whether external walls or partitions, advising you to use them as little as possible, in fact never. But half timber work has produced facades of visible woodwork -- a construction much preferable in every respect, with a well marked place in architectural art.

Now in general, all half timber work consists of principal and secondary posts P, stronger corner posts, plates S at the levels of the floors of stories, struts, sills and lintels L for the openings; then between the principal timbers are studs G, part of which must be inclined to tie and triangulate the construction (Fig. 527).

This is the entire principle of half timber work, and with all the frequently charming decorations added to it, you will find its entire application in the remarkable examples, that may be cited, such as the facades of old houses in Orleans (Fig 528) and of Beauvais (Fig. 529).

The half iron framework, more useful in modern construction, is also composed of principal members, variously arranged and connected, and of filling parts, generally of bricks. It may be said, that from the point of view of composition, the iron framework is a brick wall, but it is a brick wall with its stability especially due to the metallic members of its framework. Its function is very important in partitions, walls in small courts, etc., as well as in structures having an industrial character. Designed with a knowledge of the req-

[illegible] of magnificence, in which a brightness [illegible] also first [illegible] the industry of [illegible]. Then, after, by [illegible], that it is sold [illegible] or not [illegible] but by [illegible] as little skilled in the [illegible]. If one is [illegible] to decorate it, this can [illegible] with the [illegible] of [illegible], and in [illegible] actually prohibited from the use of the [illegible] really a [illegible] element, and perhaps it is [illegible] there is no other function, it is [illegible] architecture of the future in a metallic [illegible] that the era of the [illegible], that we have [illegible] also, is not yet ended.

In this rapid review there is no logical order to be f[illegible] and I pass directly to [illegible], the [illegible] of the Renaissance, marble work played a [illegible] part in marble [illegible]. [illegible], it was in [illegible] in the age of Louis XIV; Versailles and Trianon [illegible] enormous quantities of marble.

[illegible]

[illegible] because [illegible] because preference to the other stones for some [illegible]; the [illegible]

[illegible]. Nothing is to be said from this point of v[illegible] of Versailles, [illegible] and [illegible] white marble, which is a [illegible], so [illegible] of [illegible], but in reality [illegible] there is less difference between marble of [illegible] and other stones, than between hard and soft stones.

[illegible]. The marble presents a quite different [illegible] effect is of color. The infinitely varied [illegible] of marbles is well known. Let us say at once, that it is to be understood, without [illegible], all that [illegible], or [illegible] of [illegible] that [illegible] are not marbles, are marbles for [illegible] of view of colored [illegible], marbles [illegible], in [illegible] and [illegible]. [illegible] uirements of construction, it allows a thickness much less than that required by masonry of even very hard stone, to carry considerable loads. But it is cold -- or hot -- and it must be recognized as little suited to the architecture of facades. If one is tempted to decorate it, this can only be done with the required arrangement of verticals and horizontals, without great results, and in vain decoration is lost th economy resulting from the use of the iron framework. It is really a utilitarian element, and perhaps it is wise to require from it no other function. It is sometimes said that th architecture of the future is a metallic architecture, but I hope that the era of the facades, that we have learned to admire, is not yet ended.

In this rapid review is no logical order to be followed, and I pass directly to marble work. Among the Romans and the Italians of the Renaissance, marble work played a very important part in architecture. With us, it was in greatest favor in the age of Louis XIV; Versailles and Trianon employed considerable quantities of marble.

Marble work then possesses two elements of richness, form and color. For many monumental structures of antiquity, and even nearer to us, white or nearly white marble is merely a hard and fine stone, admirably adapted to sculpture, chosen because preferred to any other stone for monuments desired to be perfect; the Parthenon and the other monuments of the Acropolis, great Roman temples, palaces of Siena, Cathedral of Milan, etc. Nothing is to be said from this point of view. Then at Versailles, certain stairways and balustrades are of white marble, which is a rich material, an opportunity for sculpture or finer mouldings, but in reality for the architect is less difference between marble of uniform color and hard stone, than between hard and soft stone.

Where the marble assumes a quite different character is when its effect is by color. The infinitely varied coloring of marbles is well known. Let us say at once, that by marble is to be here understood, without adhering to mineral composition, all hard stones, colored or capable of polish; granites that chemically are not marbles, are marbles for us. From this point of view of colored architecture, marbles correspond to two uses, in blocks and facings. With blocks are con-

structed columns, pedestals, balustrades, etc.; the use of colored marbles for architectural members requires some indications.

As a general rule, of colored marble is not made what comprises mouldings or sculpture having a monumental function; thus in a colonnade, the bases and capitals will be of white marble, as well as architrave and cornice; the shafts and the frieze may be of colored marble. In a balustrade, the rail and plinth will be of white marble, the balusters in colored, and so of the rest -- yet without making this general indication a strict rule.

Another suggestion of experience; plain or nearly plain marbles are most monumental, variegated marbles with violent contrasts being suitable for caprices or small objects. Great colonnades were numerous with the Romans; when their shafts were not fluted or of white marble, granite is particularly seen (Pantheon, Temple of Venus and Rome, Temple of the Forum of Trajan, etc.), or for the Temple of Antonine and Faustina, of a very ornamental Cipolline marble, literally "onion skin", whose large veins do not change the character of uniformity.

Colored marble very rarely lends its aid to sculpture, for it is almost necessarily lost, unless in very strong relief or in marble of quiet coloring. It is not the effect of color, that injures the effect of the sculpture, but the accidental veining. The sculpture is as perfect in the red antique or the plain black as in the white; it is lost in the black antique, a very ornamental marble, unsuited to the delicacy of the chisel by the violent contrasts of black and white.

As for facings, whether on floors or against walls, many have been made in great variety. On the walls has already been evident, that iy was the decorative method employed by the Romans; an example remains in the interior of the Pantheon (Figs. 530, 277). It is to be said, that this ornamentation must respect the architecture, accent and not contradict it I shall later have occasion to speak of the marbles applied to the facades of the Cathedral and the Campanile of Florence; it is always the antique tradition with less variety in the marbles, a less important matter, that one is tempted not to believe; all the marble work of these facades of Florence with such rich effect, is made with but three marb

Modern Italians have made great use of marble in general. Some examples can be judged by you; the Tomb of S. Theresa at Rome, the Church S. Martin at Naples (Fig. 531), the stairway of Caserta to be given later, etc. Especially at Versailles in France may you see examples of beautiful marble work, notably in the marble stairway. From the moment that you see them, it would be useless to illustrate them, every representation in such a matter being necessarily quite insufficient.

For floors, we find the ancient mosaics, the celebrated pavement of S. Clement at Rome, of S. Mark, of Palermo, etc., and then the endless series of tiled floors. There again the richness of the marbles does not produce the monumental character. A colored pavement is elegant, if arranged ingeniously in compartments; monumental strength will rather be found in the pavement of uniform color, with great slabs of marble or of hard stone.

Finally, marble with inlays inserted in the stone has been employed, a sort of marquetry termed Florentine mosaic. Although is rather marble work for furniture, it is also done in architecture, as on the episcopal or abbatial throne in Church S. Domenico at Naples (Fig. 532).

In architecture, for a kind of equipment, fireplaces, altars, pulpits, etc., the use of marble work is infinitely varied. Then is especially exercised the imagination and sometimes caprice; also frequently elevated monumental expression A remarkable example is the ambo or pulpit of the Basilica S. Clemente at Rome (Fig. 533).

This very brief history of marble work comprises a single theory; colored marbles are used for color effects, and these must be designed by the architect in the interest of his architecture to produce a happy rendering. But nonsense would here be very dangerous, and enormous expenses for marble work might only render insupportable what might perhaps have been very tasteful without these unfortunate marbles. The architect must not lose sight of the architecture.

I finally add, that marbles in the open air are not durable with us and at least quickly lose their coloring. Perhaps it would be wiser to say -- with regret -- that this kind of decoration is not made for us. In any case, the more resistant marbles must be selected, not forgetting that one works for a

very brief future.

Joinery plays a very great part in architecture, ensuring the closing of edifices by doors and windows, blinds and shutters, also supplies them with paneling.

I cannot write a treatise on joinery, but only remind you that its design must contend with the inevitably increasing scarcity of wood. In general, simple or rich, if not glazed, joinery consists of frames and panels. This is true of doors, shutters, paneling and furniture. The frame is usually treated simply, and the panels receive all the richness in decoration, that you assume for them.

Simple or ornamented, the panel must be allowed its natural shrinkage without splitting or tearing the frame, the latter allowing the panel to move with some freedom. This is by mean of the grooving (Fig. 534). Assume a paneled wainscot to be decorated by projecting mouldings, sculptures, etc., grooved into the frame. If it shrinks, the distance a a' increases. But if the groove be sufficiently deep, the panel will not l leave it, and at the same time being free to shrink, it will not split as it would if fixed immovably to the frame. Thus never indicate it as at A in Fig. 535, for when the panel sh shrinks, a very objectionable opening is left.

That is nearly all, that can be said in general; now for its application. I believe the art of joinery to be especially a French art, for I do not think that elsewhere may be found works equal to the joinery of the Cathedral of Beauvais, at Anet (preserved at School of Fine Arts) or Ecouen, the chamber of Henry II at the Louvre, the doors of S. Maclou at Rouen (Fig. 536), or at a later epoch the old doors of the Sorbonne (Fig. 537), and such admirable work of Versailles and of many other edifices. I can neither cite all nor show all that I cite.

An important point is to place the movable joinery. In ancient monuments in the epoch of very thick walls, the doors and shutters could generally open against their jambs, and boxes were arranged to receive them. For internal doors, this arrangement could not be improved; at Versailles when a door was opened between two rooms, its leaves were swung against the thickness of the wall and fitted in a box, decorating the splays on each side in harmony with the soffit of the

same opening, also generally of joinery. These monumental arrangements are rarely possible in our modern structures, and the doors and windows generally open into the rooms. For the doors, the choice of direction of the opening is very important; it is necessary to prevent their striking against each other, or that they interfere with the furniture, etc. This study should and must be made in the plan, but no rule is possible in this matter. For blinds or external shutters, their opening against the wall is only possible if the walls are plane, as frequently seen in the architecture of the tim of Louis XVI. If the blinds open against the architraves or other architectural motives, nonsense results, and it is better to have recourse to blinds in folds, that shut against the side of the window. But a little greater width of the opening must be arranged (Fig. 538).

Paneling forms a magnificent covering of the walls, but calls for no particular theory, for this always [illegible] frames and panels. There are very beautiful examples and in great number. Those of Mansion Soubise (Fig. 539) are among the number of the most remarkable.

Finally, the ceilings have afforded opportunity for very beautiful work in joinery, or carpentry and joinery combined; with an arrangement once decided, there must be placed a general framework ready to receive the panels in their different planes; Here again I cannot indicate rules, but have already shown you a beautiful example of the great hall of the Palace of Justice at Rouen (Fig. 420). In metal work, I should enter into too many details. Besides, simple or rich, metal wor has no effect on the composition. This is a question of prac tice and experience. But the metal work assumes a monumental importance in grilles, fixed or opening. The great fixed grilles are constructed with piers of stone, the metal parts being in a sort merely fillings more or less rich between the piers, or the piers themselves may be of metal. In that case, however strong they are, they do not prevent the deflection of the grille, unless they form actual buttresses at certain distances. In simple and yet very monumental treatment, I will cite the grille of Val-de-Grace, or the similar one of the National Library on Rue Vivienne. Note in passing, that when a grille is an external enclosure, it should

be so designed as to not facilitate climbing over it. Then should be avoided intermediate cross bars and ornaments furnishing a foothold.

Opening grilles are composed in similar fashion, frequently with a solid base. But here especially are required strong piers. The leaf of a gate is heavy, and when opened at right angles, it tends to overthrow the pier, which should then be furnished with flying buttresses or great consoles staying it inside. Grilles have often been very richly treated. It suffices to cite those easily seen, on Palace of Justice, at the entrance of the court of honor of Versailles; also the internal grilles of the Cathedral of Amiens, or the celebrated grilles of Nancy (Fig. 540).

The railings of stairs and balconies have given places for very pretty compositions, but I should exceed my limits if I enlarge on such a varied subject.

With metal work is connected the wrought and cast iron architecture of halls and porticos. It permits wider proportions, smaller points of support than masonry does. It is then suitable for light porticos, like the passages for utility in asylums and hospitals, schools, etc., on condition that its proportions are frankly those required by metal. Never make in metal an imitation of stone architecture; The lintels are here beams or shapes adapted to wide spans, and their rational form is straight and not arched. Yet the arch would be proper if the hall were to be covered by curved vaults. Thus is understood the fine reading hall of the National Library (Fig. 541), one of the most beautiful works of modern architecture. Likewise have been erected very interesting halls with the design of ceilings having visible iron beams. By the loyally expressed construction and the just proportions, these entireties may acquire their value. One of the most beautiful examples, that I can cite, is the great hall with several galleries in the Museum of Natural History.

But it must be stated that these designs are scarcely in the reach of beginners. We have no long traditions here, and the creations are only permitted to men, who have mastered their talent by long traditional studies, which must primarily be your programme. For all these subjects requiring iron architecture, are necessary two things; to know the construc-

tion, and a taste sufficiently formed to be able to create where no old errors exist. The programme is beautiful and seductive; when you enter on it in your turn, know how to assimilate it completely, and bring to the study of metal the same spirit of truth, that you should be convinced, is always the guide of the true architect.

I shall not treat of plumbing, heating, etc., excepting later in indicating the foresight imposed upon the architect in his compositions. To enter into details would be to make a cyclopedia of construction; each of these subjects merits a special work, that you will study when necessary. Neither is anything to be said of lighting at night, -- always excepting the needs of composition -- of painting, stucco, etc. This is no longer the composition of architecture but its execution, and I do not wish to exceed my limits, already sufficiently vast. I cannot pretend that this modest work may take the place of an entire library of architecture.

Thus I have reached the end, or nearly all of what I have called the Elements of Architecture. Certainly, I have exhausted no subject, and must have passed too rapidly over all. It is the Theory of Architecture, that is truly infinite; nothing shows better than this course the enormous mass of knowledge necessary to the architect. In one course can only be stated principles, not giving you recipes; my ambition is to make you artists, who think and meditate; The details of the course may escape from your memories; it matters little for you will recover them, if you indeed possess these guiding principles, that are the essence of all beautiful things, of all that I have defined as classical, of all that your designs should be.

Then the first part of this course is terminated, doubtless the driest portion; permit me to say, that I have not been able to prepare myself in advance, unless by the long preparation of forty years of studies, and that I have almost had to improvise before you, not only the words, but the method and the connection of the subjects.

At this stage, a professor should ask himself, the only one that profits in instruction: -- "Have I been useful?" Very sincerely, I hope.

In our instruction are two parts, the pure doctrine, in-

trinsic and eternal truth, and also the truth of the present hour. The long experience of your studies permits one to know what to emphasize, and on the other hand, what does not need to be taught to you; thus this course should not be today what it will be in ten or twenty years, or what it would have been ten or twenty yeass since. It must correspond to the general state of your studies, and especially to your tendencies.

Well, if in certain respects -- skill, ingenuity and resear -- the School is in constant progress, on the other hand the prepossession of the brilliant and sometimes of the eccentric early turns your minds away from the primitive verities, you will lose sight of the principles, the functions and aim of architecture, the School becoming more brilliant and fanciful than serious, and it is a disappointment for you, when a programme invites you to treat one of those magnificent subjects, where everything must be considered and meditated. What you need then are strong and severe studies, austere instruction, a recall to the principles. The idea that you yourselves make your art is not sufficiently elevated, but it is necessary to show you, that its nobility is not composed of caprice and ephemeral fashion, that its laws exist and are profoundly logical, that its most beautiful works witness and demonstrate them.

Are not your thoughts more elevated after these primary lectures? If so, my purpose is attained. It is not details that I assume to teach you; details are forgotten, and are also recovered, and besides, theoretical instruction never replaces the experience and knowledge acquired by practice in design. I have no recipes for abruptly making a novice skilful. But certain skilled persons lack the guiding principle, the directing light, and such lose themselves at random; neither the lighthouse nor the compass make a novice a skilful seaman; but what would the most skilful mariner be without the direction? Your lighthouse is the light from masterpieces; yo compass is the orientation of the great minds, that are saluted by the name of masters. And their instruction, you should understand, that I strive to transmit to you in its magnificent unity. Either I have made myself poorly understood, or you have already comprehended, that all the masterpieces fur-

nish the same advice and the same lessons, in spite of all differences of time, climate, materials, methods, and of civilization itself.

As for myself, in some thirty lectures I have spoken to you of the elements of your art to the best of my ability; I know that you will not retain all that I have said. What does it matter? I shall be happy and proud, if repassing mentally over these thirty lectures, and seeking to summarize them for yourselves, you find in condensing, that the substance, that the single word, or rather the sole desire shall be for Truth!

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